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THE TREATMENT OF INFANTILE PARALYSIS.

A Study on MUSCULAR ACTION and MUSCLE REGENERATION.

By WILLIAM MACKENZIE.

Melbourne;

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1910.

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The Treatment of Infantile Paralysis.

A Study on Muscular Action

. . AND . .

Muscle Regeneration.

WILLIAM MacKENZIE, M.D., F.R.C.S., F.R.S. Edin.

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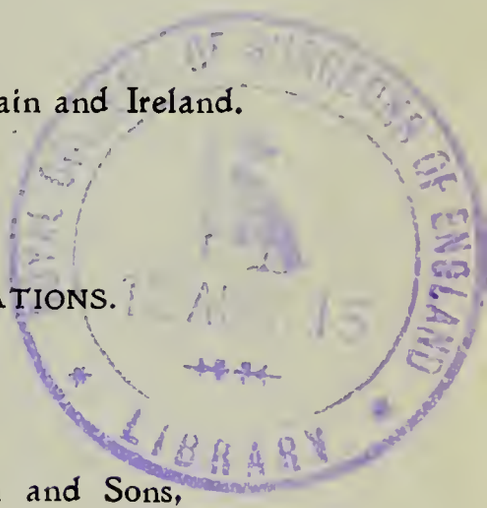

WITH OVER ONE HUNDRED ILLUSTRATIONS.

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1910.

TO

PROFESSOR DR. O. VULPIUS,

OF THE

UNIVERSITY OF HEIDELBERG.

CHAPTERS.

LIST OF ILLUSTRATIONS.

Every muscle in an animal body may be considered as a simple, independent power; and if we attend to the effects that many animals are capable of producing, particularly the motion of fishes and the flight of birds, we shall see great reason to admire the immense velocity and great force with which the muscles are contracted; and if we compare the effects produced by the contraction of their muscles with the weight of each muscle, and the part which is to move, it may lead us to conclude that there probably is not in Nature a more active, simpler power than the contraction of the animal muscles.

It is no wonder, then, that the mode in which a muscular fibre produces motion has almost universally been one of the principal researches of the physiologist, especially when we consider that the substance called "muscular" alone constitutes the largest part of most animals, and, indeed, many are wholly composed of it.

JOHN HUNTER.

INTRODUCTION.

Infantile paralysis is an affliction of world-wide importance, dating from antiquity, and is mentioned in Biblical records. It strikes its victims in all climes and in all states of society, and amid surroundings hygienic or unhygienic. Because of its early onset, it becomes at once a matter of great economic importance, since a lame member of the community is worth less in the struggle for existence than were he physically sound. On account of the anguish brought by this subtle disease into the lives of the mothers of the afflicted, the hope of cure when reasonable should not be withheld nor niggardly given.

The treatment of infantile paralysis has now resolved itself into a much simpler question than an attempt to certainly know the causation of this disease involves. The restoration to normal function of a paralysed limb in a child does not simply mean a happier child—it means a happier manhood or womanhood, and often the difference of the blighting poverty of dependence and the ability to pursue the toils of life normally. Paralysis attacking individuals in the prime of life attract more attention, but because half a lifetime has already passed before their advent, they are not enveloped by the whole life importance attaching to infantile paralysis.

It is usual to demand, before treatment is considered scientific in its application, that the exact causation of the disease be well established. The successful treatment advocated in this monograph arose through non-belief in the ordinarily accepted

theory of destruction in the anterior cornua of the spinal cord.

This monograph is written to record the success of the treatment, and to show how it is effected, and the principles for action on which it is based. Such a position in connection with many diseases might be considered an erroneous one to take up, but so peculiar is infantile paralysis in its workings, however, that it becomes necessary. A death from this paralysis is an event of great infrequency. Examination of old cases shows, not the prime lesion, but sclerotic changes, which probably do not occur under proper treatment.

There exists a wide breach between pathological statements about this disease and the clinical experience of cases successfully treated—restoring, by the education through volition, of muscular action in paralysed limbs from the zero point, muscular function.

The writer looks at this disease from an opposite standpoint to that taught in the text-books, as will be subsequently explained, and maintains that by so doing the surgical procedures—such as arthrodesis, tenodesis, joint erosion and excision, and tendon transplantation, which certainly marked an epoch in treatment, but which have been found subsequently to be so frequently useless—will be largely, if not entirely, obviated.

It is hardly necessary to state that a sound knowledge of the anatomy of muscles, as regards origin, insertion and function, is essential—nay, basic—in the treatment of this paralysis. Much of the work here embodied has been carried out at the Melbourne Children's Hospital, as well as at the Orthopædic clinics of Heidelberg University—Halle and Saale—

and Liverpool. Papers have been published dealing with various aspects of the disease from time to time, and so the treatment embodied in this work may be considered evolutionary. Sporadic cases have occurred for years in the different States of Australia; and in New South Wales and Queensland in 1903-04 the cases were numerous enough to constitute an epidemic. In 1908 numerous cases were recorded in Victoria, more especially in Melbourne and Bendigo, and it is probably safe to say that in this State, in the years 1908-09, some five hundred cases were observed. Thus there need be no apology for a monograph dealing with the treatment of the condition.

To this and many other diseases, what Goethe speaks of as Thätige Skepsis, active doubt, is applicable; "the doubt which so loves truth that it neither dares rest in doubting, nor extinguish itself by unjustified belief."

PRINCIPLES OF TREATMENT.

Within the past few years the treatment of Infantile Paralysis from the surgical standpoint has received an enormous impetus, and for this we owe a no small debit to the work of Professor Vulpius, of Heidelberg, and Robert Jones, of Liverpool, since, with the introduction of tendon transplantation and arthodesis, many patients with muscles regarded as hopeless have had the function of affected limbs partially or completely restored. Contractures, also, too often allowed to occur, we emphasise the importance of overcoming or preventing, it being recognised that the weaker or recovering muscles were not guarded against the action of the stronger or recovered ones.

Strangely enough, both the operations of arthrodesis and tendon transplantation, which have really laid the basis for our latest treatment, are at present the subject of much destructive criticism, in which Kermisson and the French school are not alone, and it may be mentioned that without the help of either operation we have had some interesting results. We see a case in the morning that has walked for years with crutches owing to a dangling, paralysed limb. A piece of cardboard under the knee, to stiffen it, tells you whether the patient can swing his limb (and I have never yet seen a case that could not in some degree); you apply a caliper splint to the limb, converting it into one rigid piece, and the same day the patient walks without support. Furthermore, the writer has seen children with flail ankles, knees acutely contracted, and the hips also even beyond a right angle, which have been gradually straightened without operation—thus conserving tissues—and, by means of caliper splints and a light spinal support, enabled to walk even without crutches.

Nevertheless, it has always seemed to the writer that the true treatment of this disease was that at the onset. Frequently these cases are not brought to the physician until some weeks, or even months, have elapsed, when too often it is a question of

remedying a deformity; but in Melbourne recently an epidemic of this disease occurred, which spread to many of the inland towns of Victoria. Thus an opportunity occurred of adopting some definite lines of treatment, and so a comparison could be instituted with former methods.

The pathology of this condition has been somewhat misleading. Briefly put, we have been taught that in this disease certain cells of the anterior cornua of the spinal cord were attacked—a remarkable instance of germ selectiveness; that these cells preside over muscular function; and that with the reaction of degeneration in the muscles there was no hope of recovery, since obviously enough the anterior cornua had not recovered. Yet we now know that such muscles are often recoverable ones, for to me—and in this no less an authority than Vulpius agrees—it seems we are unable, electrically or otherwise, to estimate the recuperative power of any voluntary muscle in the same way as we are unable to absolutely prognose whether an acute illness will be fatal or not.

After all, the possibilities in function of a voluntary muscle must be enormous. Nature has provided us, not with one, but with two upper limbs. Their action is not continuous—it intermits—rest is essential—thus a comparison in function is permitted, and so improvement in action is effected; in this way differing from the heart, whose function, except as regards contraction and dilatation, is incapable of improvement, since it never rests from the cradle to the grave. Hence, as a deduction, one was justified in assuming that, since the disease, relatively, was, as a rule, associated with little general reaction, and that the old muscles regarded as hopeless could recover, there was not the "cell destruction" too often assumed, and that inherently there must be latent possibilities even in a voluntary paralysed muscle; since Nature, unlike as in the heart muscle, made the acquisition of function a gradual one—in other words, the condition could be regarded as a recoverable one, provided the resumption of function of the muscle were along the gradual lines of development of power of action. Hence, though anatomically we speak of a

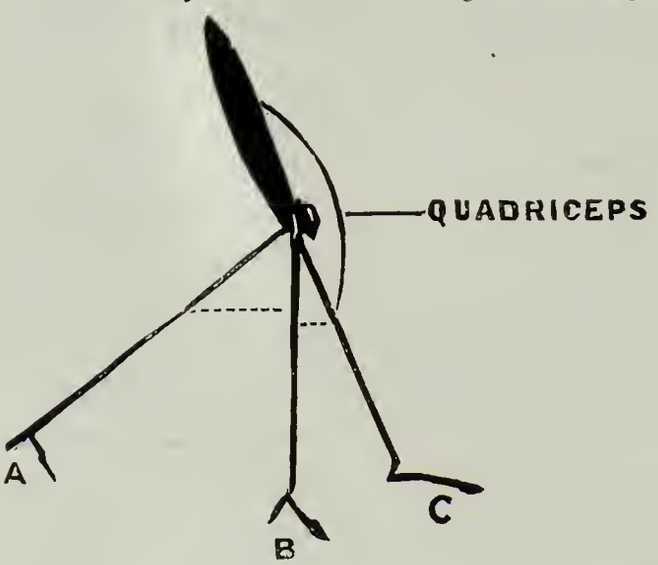
muscle as being flexor or extensor, we really refer to the maximum function of the muscle, and the question arises as to the recognition of the minimum of muscular function; for it is only by the recognition of that minimum that the muscle may ultimately be coaxed up to the maximum—the ideal.

Thus we begin with the recognition of what may be termed the zero position of muscles. To speak of a muscle as being in the zero position—i.e., a position of rest, and hence best for the commencement of minimum function—is, I apprehend, erroneous, for we realise that paralysis of the muscle does not mean death of the muscle, and hence there can really be no such thing as rest of muscle, else there could be no hope of encouraging voluntary muscular action; but, since no less a science than geometry is founded on the assumption that a line is length without breadth, we are justified in applying the term zero position in explaining principles of treatment. At the outset then, the treatment adopted in this monograph began as a deduction, for which I was justified by numerous Hunterian precedents. Deduction I recognised to be a dangerous method when the physical existence of a child was at stake, unless corroboration could be obtained later on an inductive reasoning. That I obtained such corroboration will be explained subsequently.

The working hypothesis was assumed that the disease was a recoverable one; that the amount of work a muscle was asked to do might be in excess of cell recovery; and that the resumption of work gradually —i.e., presumably pari passu with cell recovery—was the essential factor; in other words, to regard the proper treatment of the muscle as the probable solution of the difficulty. The muscle is placed at rest, it is asked to resume work gradually, and any tendency to counteract that, such as over-action of other muscles, is prevented at the outset. By massaging —e.g., a paralysed deltoid, with the arm hanging— we are asking damaged cells to begin work at the greatest disadvantage; in other words, asking a baby to climb a hill before it has learned to walk. We ask our muscles to begin work at zero. They are

placed at complete rest, and the resumption of work should be gradual, and is easiest along a straight line.

In the lower limb, undoubtedly the most important muscle is the quadriceps extensor of the knee. At the hip, even in extreme cases, there is usually sufficient muscular power to give a swing at that joint enough for ambulation. But, even though all five flexors of the knee are sound, yet with a paralysed quadriceps the patient is unable to walk. In the case of the quadriceps, the zero position would be the extended knee, with the patient lying down. Hence, if that muscle be affected, it should be placed in this position by means of a splint, and the earlier treatment is commenced the better. If it be an old contracted case, the contracture must be overcome (and this can always be done gradually without operation, as will be subsequently explained), and the quadriceps placed at zero, before any commencement can be made to see if the muscle has really recovered. It may be stated, then, that a muscle is rested only when it is placed in a position where its work is zero, and its origin and insertion are as nearly as possible on a level, since the resumption of function, which should be gradual, is always *easiest along a straight line.*



The zero position is represented by the line C. The maximum extension would be from the flexed position, A to C; but why ask the leg to go through the arc of the circle A C before we know whether it can go from B to C? The contracted knee is a neglect

of that principle, as is perfectly obvious. With a flexion to B, we should extend to C, and so gradually till finally from A to C; but it is quite fallacious, as is too often done by masseurs, to ask a weakened quadriceps to extend from A to C *ab initio*—in other words, it is incorrect to flex the knee beyond a point at which extension fails, i.e., at which effort becomes manifest.

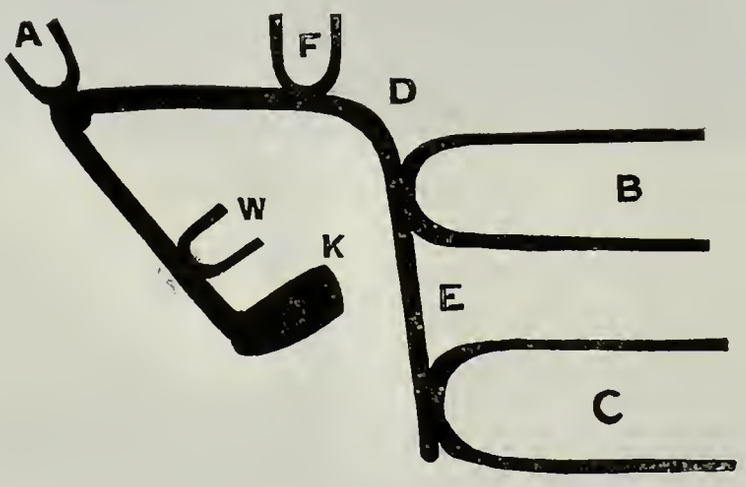
The Ideal Recovery.

Still, we have not attained our ideal, viz., the ability of the patient, when lying on the back, to raise the

Recovery when turned on Side.

heel off the ground with the knee extended; but, turn the patient completely on the opposite side, and so alter the leverage, and our patient will be able to swing the limb from the hip in one piece, i.e., with the full knee extension; and hence, to get back to our ideal, we must gradually alter the tilt of the body, which can be done by means of a pillow, from the lateral to the prone position, and so finally the maximum is reached. Then will the patient walk and stand with confidence, otherwise he will need support; if at the minimum, something to render the knee rigid, to permit of a swing from the hip; and between that and the maximum some form of support which only allows flexion at the knee corresponding to the power of extension.

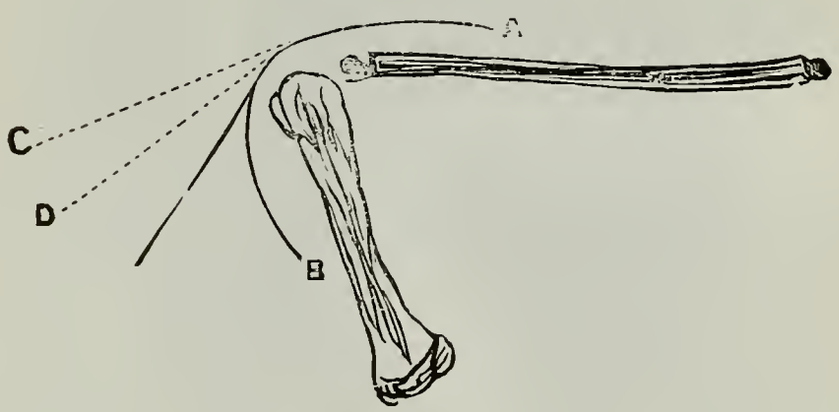
This method, as systematically applied to cases of upper limb paralysis seen shortly after the onset, is exemplified as follows: The limb is immobilised when seen by means of the accompanying splint



B and C	Wings two-thirds round chest.	A	Wing at elbow.
E	Stem alongside of chest.	W	Wingwrist.
D	Under axilla.	K	Hand piece
F	Support shoulder.	W and F	On same level.

Thus the arm is kept elevated at a right angle, as representing zero for the deltoid. In this way we also rest our biceps, augmented by turning the splint in at the elbow, it being important to remember that the fractured clavicle position, since the biceps is in

relation with two joints, does not afford it complete rest. The forearm is slightly supinated, to prevent over-action of the pronators, of which there is a ready tendency, and by means of the hand-piece the extensors are relaxed—slightly with weak flexors, but more so if strong. Thus we take all work and all strain off the muscles which, in our experience, are invariably affected, and kept the limb in this position for at least a week. On removing the splint, the limb is kept supported as before, and the arms slightly lowered. If it can get back to its original position, the arm part of the splint is lowered, and similarly with the forearm, and so the amount of work the muscle is asked to do is quite in keeping with what we assumed was cell recovery. In this way, week after week, the amount of muscular work is gradually increased.



With the arm hanging at the side, we have the humerus in the position where, to raise it, the deltoid is asked to do a maximum of work. The position A B represents a deltoid capable of doing that work, but ours is incapable. The deltoid being paralysed is really in that position overstretched to its greatest extent. It cannot pull right up the hill. We place it at a right angle, and keep it supported there. We bring it a little way down the hill, and make sure it can get back without going further, i.e., we go from D to C, and not from B to C. We regulate its work by its degree of contractility, i.e., by its degree of recovery.

Personally, I prefer to test the limb on a pillow, with the patient lying down, and it is surprising in

old condemned cases what a large amount of deltoid power there may be when tested in this way. Though

Able to Raise Limbs supported by Back of Chair.

action, however, may be perfect lying down, yet sit the patient up, alter the leverage, and we find the limb cannot be raised; hence, not only must we work a deltoid from the minimum to the maximum to functionise with the limb in the easiest position, but similarly deal with the position of the limb relative to the rest of the body. It is absurd to test a child with a weakened deltoid and biceps for the first time sitting upright. Commence in the reclining position, then gradually raise the body by means of pillows to the point beyond which effort becomes manifest, and so we arrive at the upright position. In the case of the biceps, mere flexion of the forearm does not rest it. We have the long head crossing the shoulder

joint; and, in addition to elbow flexion, the arm should be raised as in deltoid cases. With the patient lying down, and the limb placed in this position by means of a pillow, it is surprising what an amount of function a biceps may have which we regard as hopeless, and as improvement takes place, the shoulder can be lowered and elbow flexion lessened, and the patient gradually assumes the upright position.

Able to Raise Limbs standing up.

The treatment may be summed up as the encouragement of voluntary muscular movements within functional limitations, and at the outset we assumed the disease to be a recoverable one, quite apart from any question of causation. And, although we may think that work at the minimum is slight, we must remember it really represents the maximum function of the muscle for the time being, and as such may soon exhaust; in the same way as the ordinary individual

would soon tire if asked to continue flexion and extension of the forearm to the full extent. At the outset, I wish to join issue with those who describe present day treatment consisting merely of relaxation of muscles, splinting and massage, with "resisting exercises" as a side issue. At once let it be stated that these are merely conveniences—only pawns in the game of recovery. You have an extensor muscle paralysed; it is overstretched, and so prevented from functionising. To place it in the position of complete relaxation and expect it to take in its slack is to ask that muscle to do the greatest work possible, i.e., to contract within itself, without leverage to assist it, and hence at the maximum disadvantage. By having a muscle relaxed completely for a certain number of hours a day, we simply satisfy ourselves that there is no mechanical interference with its action, as I have proved in the case of foot-drop, by leaving the muscle in the stretched position and obtaining recovery, but having no interference with its action by dividing previously the tendo Achillis; and, furthermore, in the case of flexions of the hand, I think it best to initiate recovery from the extended position.

Mere relaxation, then, which really may be summed up as the maximum work with the minimum advantage, does not train a muscle to functionise; and, furthermore, the mechanical interference with function from contracted antagonistic muscles is not the only one to contend against. Massage is usually considered by the majority of physicians as quite the basic part of the treatment. Yet I am convinced that its indiscriminate use has done a considerable amount of harm. Its popularity undoubtedly lay in the fact that one felt that in a disease apparently so hopeless something practical was being done. And how, in this disease, is it usually carried out? The weakened deltoid, unable to move the arm one inch, is spatted, hacked, pinched and kneaded with the arm hanging down the side: and numerous revolutions are performed at the shoulder, as though, forsooth, the disease were in the joint. The extensor of the knee is treated by having the joint it is unable to move half

A Quadriceps that Four Years' Relaxation failed to benefit.

an inch flexed to an acute angle, and the elbow is bent and extended to recover a biceps with force, and subsequently the limb allowed to hang by the side.

There is no gainsaying the fact that that has been the method applied—applied to coax a muscle struggling for its existence to functionise—applied to keep up the nourishment of the muscle " by stimulating the blood supply " till the diseased cells of the anterior cornua recovered, when the muscle would commence to functionise. As if, forsooth, the life or death of the muscle depended on the blood or tone function could supply it with in half an hour each day. And in that time what damage could be done!

No lightening of the load for the horse—only beating it and pinching it—to, forsooth, drive it up the hill when it couldn't even move along the level.

A Result in spite of years of Electricity and Massage.

It would have seemed heretical for such writers to have suggested that this treatment might have helped to produce the cold, shrunken limb, and not merely an atrophied cell, and to wonder would such a condition occur with mere rest of the struggling muscle. It may be stated that until a muscle has recovered it should only be massaged in the zero position, and in the mildest manner possible. It is erroneous to expect massage to initiate function; but it may undoubtedly strengthen function once that is found to be present in the muscle. Thus, in the upper limb, where there is an obvious gulf between the performance of muscular function when the patient lies down and sits up, there should be no exhibition of massage till, for instance, the whole of the muscular functions can be performed lying down, and then it should only be used on the limb placed in a similar position to that occupied when in the upper extremity splint.

The muscle enlarges, not from the amount of work done for it, but from the amount of work it itself does. Mental effort is essential—it counts for everything in the treatment—and in three weeks I have seen a limb increase in circumference one-third of an inch that had remained stagnant under massage for three years.

The importance of the mental factor in securing recovery of the affected muscle is of prime importance—it counts for everything.

In experiments on animals, this factor explains their limitations—for no analogy can be drawn between results where guided mentalisation governs volition and where it is absent. As regards the results of treatment, it is not intended here to enter into statistics, though in connection with the upper limb this will be done later; but in the lower limb, of which the instances are many times more numerous, the results of treatment carried out at once were uniformly satisfactory; and, strangely, enough, as opposed to the upper limb, the majority of old cases responded also.

I have spent as long as twenty-one weeks, on these lines, on infants eighteen months old, with complete paralysis of both upper limbs, with the satisfaction at the end of seeing them raise both heels off the ground with the knees extended.

Such cases, under the old treatment of electricity and massage, were invariably condemned to a life-long crutchdom.

Although in the treatment of disease theory cannot be separated from practice, nevertheless it is eminently dangerous to state, as Cullen once did, that it is unimportant which came first. A medical practitioner should not allow his observations to be controlled by his theories. At this juncture, then, the position may be thus reviewed. The disease was regarded as essentially a central one; and, since the cells of the anterior cornua control muscular function, destructive processes in the anterior horn region entailed loss of muscular power. The cornual condition might possibly improve. In the hope that it would, muscular tone was maintained for a longer or a shorter period by massage and electricity, and so it was expected that muscular waste would be thus prevented. But, nevertheless, the undoubted and undeniable fact remained that results as regards nutrition and muscle action were eminently unsatisfactory. From certain observations made, it was deduced that perhaps the muscle, and not the cell, was

the dominant factor; in other words, not merely was the disease a recoverable one as a rule—not merely did the cells recover, not merely was the recovery of muscular action gradual and not sudden, as was thought —but that in infantile disease as we know it (i.e., a non-fatal disease) the trouble might not necessarily be in the cell, but actually in the muscle itself, the central changes seen in old cases dying from other diseases, being either atrophy from disuse, or else the known tendency, of which there are numerous examples in medicine, of disused tissues to become the seat of disease.

Mere deduction in medicine, however, even though supported by results, is obviously unsafe ground to tread. Philosophically it may be sound enough, but in practical matters such as this theory alone should be feared, just as in scientific matters it should be respected.

Nevertheless, in spite of numerous difficulties, certain facts are here adduced to place what was formerely theoretical on an inductive basis, and these may be considered under various headings.

Difficulties of Investigation.

Though known from antiquity, the investigation of this disease has always been beset with difficulties, before which diseases like syphilis and many others pale. With syphilis, for centuries the disease itself was well recognised, also the mode of infection and the site of inoculation, so that the only factor remaining was what passed from the infector to the infected. Furthermore, the supply of material was unlimited. But here we have been simply faced with a result—one factor out of four—the infecting agent, the infector, and the site of infection being the gaps to be filled in. And, to add still further to the difficulties, material for investigation is as a rule scanty, and cases are rarely seen in that pre or early paralytic stage which, to my mind, means everything in the investigation of cause. Moreover, the disease, as we know it, rarely runs to a fatal termination.

The Logical Aspect.

The study of medicine being an art and not a science, not only are there two methods of investigation—viz., the inductive and deductive—but each method may lead to different conclusions, and, curiously enough, that is so in this disease. Bell's capital discovery that the anterior part of the cord was motor and the posterior sensory seemed to give an easy solution to the pathology of this condition. Here was a disease with loss of muscular power, absence of pain or sensory symptoms, the cord showing post-mortem atrophy of motor cells corresponding to the affected muscles—obviously a disease of the anterior cornua. Hence treatment was directed towards maintaining the nutrition of muscles by means of electricity and massage, in the hope that the cells might ultimately recover, when the muscles, presumably, would resume function. The fact that they did not in the majority of cases seems to have been of little import. Assuming again deductively that this is a germ disease, it is only a further step for Flexner to attempt to isolate an organism in the anterior horn region, and produce a serum whose injection will hasten cell recovery or lessen destruction. Flexner does not seem to be impressed with the fact that curing a disease and the resumption of function of an affected area are distinct factors, this disease having, unfortunately, its artistic as well as its utilitarian side. Nature as a rule has done the former when she reveals to us the nature of the case. Such is the accepted view of this condition; but that it is logically false it will be my object, on an inductive basis, in this paper to show.

Effect of Rest.—The Action of Muscles.

If the above views be correct, then to rest a muscle without massage should be fatal, generally speaking, to its recovery. But that is not so, as has been pointed out. We really rest a muscle when we ask it to work within functional limitations. It must work; work must not be done for it. If we recognise the

fact, as already referred to, that the zero position is the one for the muscle when out of action, and that to gain a maximum function we must begin at a minimum and work up to a maximum—in other words, recognise that the acquisition of power is gradual—then we can confidently expect, seeing the case sufficiently early, that recovery in any affected muscle, all things being equal, should be obtained. Take, for example, the quadriceps extensor. It has been the one muscle that seemed rarely to respond to treatment, and to overcome a flail joint, arthrodesis, tendon transplantation, or even excision of the knee-joint, have been advised. Its cells once affected seemed never to recover, and yet it is a muscle that responds particularly well to treatment. I can confidently say that I have yet to see the quadriceps, even though the knee has been contracted for years, that, although it fail to come up to the maximum standard, will not recover to a large extent. Regarding the cell and disregarding muscle action, it seemed to be the most hopeless of all muscles; but, with a regard of muscle action and disregard of cell, it is the muscle that in my hands has given the most excellent results.

Results of Removal or Division of Deep Fascia over Muscles.

Apart from the quadriceps, it is common enough to see other muscles condemned, both on electrical and utilitarian grounds, as hopeless of recovery; yet the muscle may ultimately be brought into action. The cells presumably are gone—gone often for years—yet why does not the muscle waste? Why should it ultimately be coaxed to work? Yet that it can is the rule, and not the exception. Recently, five instances of paralysis affecting the extensors of the foot, without movement of the toes for two years, were seen, in which an incision over the muscle origin revealed in all abundance of muscle tissue, and in two cases of division and three of removal of the deep fascia room was given to the muscles to expand, the fascia

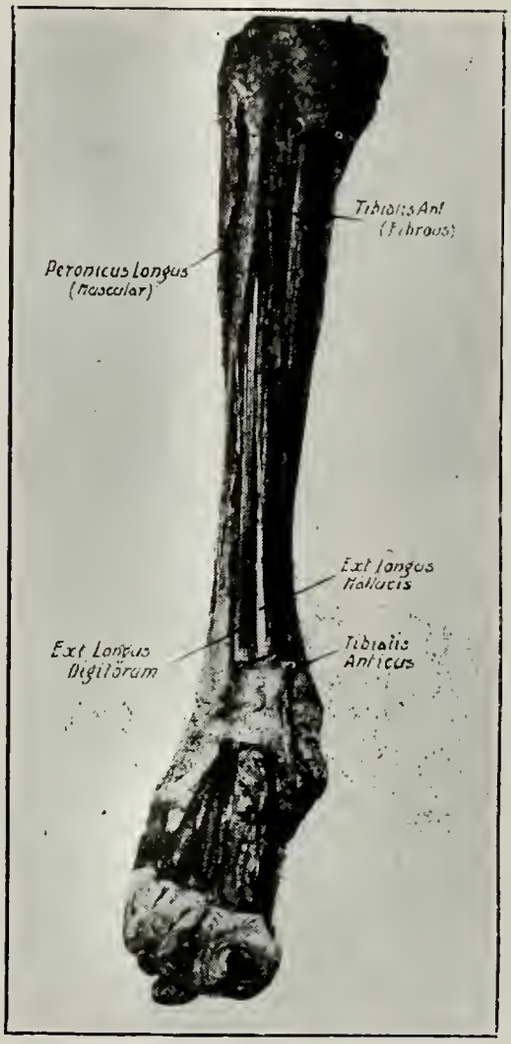
being simply contracted down on the affected muscle. The result was in all recovery in a few weeks of extensor power. In another of eight months' standing, with foot drop, on incision of the fascia an anæmic mass was seen, which, on its removal, swelled up for about one-third of an inch, presenting itself as apparently useful muscle, as was shown subsequently by action and by the miscoscope.

Presence of Pain.

In the differential diagnosis of this disease—e.g., from multiple neuritis—stress is usually laid on the absence of pain or sensory symptoms in this disease. Opinions are slightly altering in this respect, and pain, if severe, is frequently referred as due to associated meningitis. As a matter of fact, the disease may be regarded as a painful one, and for weeks I have known cases regarded as rheumatic. My own opinion is that the majority of mothers will state that the handling of the limb early is associated with great pain, due, not to meningitis nor myelitis, but to the fact that the mischief is actually in the muscle itself.

A Museum Specimen of Talipes Valgus.

In the Department of Applied Anatomy is a specimen of talipes valgus from infantile paralysis, showing the everted flattened foot, hypertrophied peronei, and atrohpied tibialis posticus and anticus, but this atrophy is curious, the tendinous part of each being normal, but the muscular part completely gone, and its place taken by fibrous tissue. If cell destruction, why the intact tendons, and why the fibrous, not fatty, replacement of muscle? It is obviously due to a destructive change affecting the muscle alone.



From the Writer's Dissection, in the University of Melbourne.

The Question of Age Incidence.

According to Stiles, of Edinburgh, an infant's tissue is the best for healing known, and hence we might expect good recovery of cells, and also muscle, the younger the age of an attacked person, and surely here the accepted views should have secured their greatest triumph. Yet the opposite is the case. For the adequate working of a muscle, mental effort is required. Mental effort counts for everything in the appreciation of muscular action, and, speaking generally, the older the patient the more rapid the recovery, and of this I could tabulate numerous examples. Recently I saw a patient, æt. 20 years, with left quadriceps completely paralysed in spite of twelve months' massage and electricity, yet within six weeks the accurate working of the muscle resulted in recovery.

Recuperative Power of the Upper and Lower Limbs.

In my experiences of cases treated, early recovery is much more rapid and more complete in the upper than the lower limb—a result quite opposed to former statistics. Nor is the reason hard to seek. More perfect rest is secured, control of muscuar action is better, and the easy working of the muscle from zero, so necessary for recovery, render the muscles of the forearm and hand more responsive than those of the leg and foot.

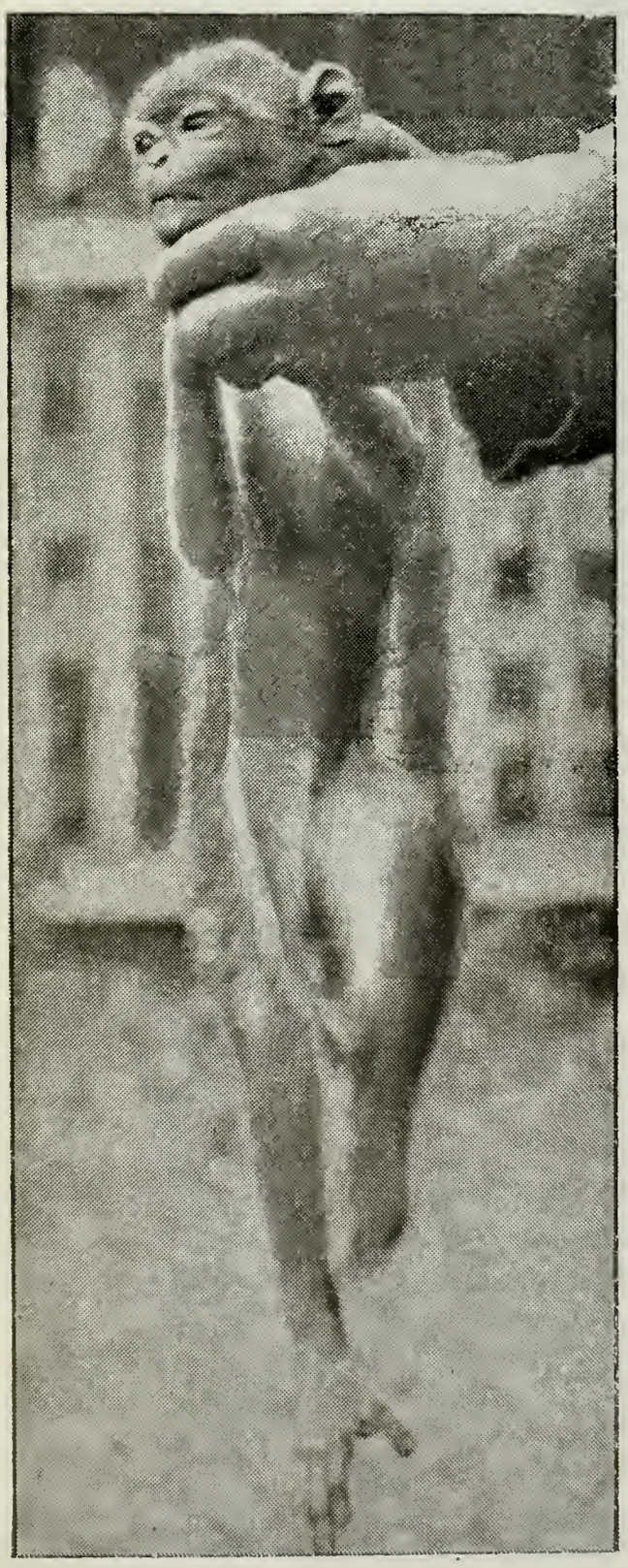
Muscle and Muscle Tendon in Recovery.

Whether a muscle is largely muscular in character, or partly muscular and partly tendinous, has an important bearing in recovery, and especially in old cases. It helps to explain why the muscles of the leg are the ones most difficult to recover, for in these, with their large tendinous character, given an affection of the muscle, obviously there is little reserve force. This is one reason why a powerful muscle like the quadriceps recovers so easily, and explains why in old cases of upper limbs (I have proved it in a case of fifteen years' standing) we may get a rapid recovery of deltoid and biceps, but a delayed--possibly absence of—recovery in the forearm and hand.

Question of Recovery in the Leg and Foot Muscles.

That recovery is often delayed in the leg and foot, even in cases seen early, and especially on the left side, will be admitted. From our point of view, this may be regarded as one of the evils of evolution--a result of the erect position. A quadriped on all fours with the limbs in the position of talipes equinus is to be envied. When man essayed the erect position, his base broadened, heel fell, and, instead of straight muscles and tendons, origin and insertion became

placed at a right angle. This is one of the explanations of the difficulty of initiation of muscular action —even by the brightest of patients—in the leg and foot, although an incision over the muscle and its microscopic examination convinces you that there is abundant muscle for foot action.



Length of Limb.

That an affected limb is usually shorter than a sound one has been brought forward as evidence of "trophic" or central origin. But the reason is explained by the fact that growth of bone is largely dominated by muscular action. Of this, according to Dr. Stapley, of the Melbourne University, there are numerous examples scattered throughout the animal world. In this respect, one may mention the roundness replacing the sharp tibial edge associated with an atrophied tibialus anticus. This fact is important, for on it we can assure parents that, by the improvement of muscular action, there will be improved growth of bone, and hence diminution of the shortening of the limb.

Inoculation of a Monkey with Muscle Emulsion.

I have already referred to the difficulty of seeing cases at an early period. After a long wait, I was enabled last February to obtain small portions of muscle from the tibialis anticus and extensor longus digitorum of an affected left lower limb in a boy three years of age, with a two days' history. From this a saline emulsion was prepared, and inoculation made by Dr. Stapley into the leg of the left lower limb of a young monkey. In spite of the usual precautions, some suppuration, with culture of the staph. aureus, occurred for the first time in connection with many experiments on monkeys. The limb was noticed helpless four days after the inoculation, the animal dragging its limb in its endeavours to escape. Later, contraction of the hip and knee-joints, with flaccid ankle and dropping of the toes, were noticed, as seen in the illustration. The paralysis was marked four weeks after its recognition, when an autopsy was made, and for three weeks no evidence of pus has been noticed. The contractures of the knee required considerable force to overcome. All the muscles of the limb were markedly attenuated, especially the two vasti and the rectus femoris. Careful sections of the spinal cord by Mr. Fielder, of the Histological De-

partment, revealed no affection of the spinal cord. One may here mention that inoculations have been made on monkeys into the cord, sciatic nerve, muscle, and subcutaneously, with cerebro-spinal fluid of recent cases, and emulsions of old affected muscles, with negative results of any description.

Results of Microscopic Examination of Muscle.

So strong has the bias towards the central origin of this disease been that, in descriptions of the condition, one meets little reference to the histology of affected muscles. Professor Gilruth, to whom I am indebted for much assistance in this work, has examined specimens of muscle obtained from living children—both recent and old—and the following may be regarded as a summary of the conclusions.

No fat cells were present in any specimens. The sections showed the presence of numbers of nuclei, with, in every case, some muscle fibres still remaining.

Increased fibrous tissue was noticed. In some a thickening of the arterioles, and even occlusions, due probably to some thrombosis being present. The distinguished Pierre Marie has mentioned hypertrophy of certain fibres in affected muscle, and due probably to compensatory excess of action. Erb regarded it as constituting the first stage of the morbid process which ends in atrophy; whilst Joffroy and Achard believed it to be "a degenerated change possibly connected with the incomplete lesion of a certain number of cells in the anterior cornua."

Conclusion.

This chapter may be summed up as the recognition of the treatment of the muscle as the all-essential in this disease. Instead of waiting for a chance recovery in the anterior coruna, and treating in a perfunctory way the muscles with massage and electricity, it recognises the fact that every affected muscle will work provided that a commencement be made from zero. It recognises that an affected limb will retain its heat, and show little waste, provided that it be rested and

worked within physiological limitations, even without massage and electricity. Work must not be done for the muscle, it must work; but the tired horse must not be whipped up the hill, it must be driven slowly, and with its load lightened. Much patience is required; results are slow in arriving in many cases, but these well merit the time and trouble spent. It substitutes for the gospel of wait and of hope that of action. It asks that the disease be looked at from an opposite standpoint, and states that by so doing excellent results will be obtained, for which such procedures as arthrodesis, tenodesis, joint excision, tendon and nerve grafting have all been advised. As regards a definite specific organism as the cause of this disease, we have always to remember a toxic agent as causative, *e.g.*, beriberi and plumbism. The disease has frequently followed one of the infectious fevers. I have seen it occur sporadically in an infant, six weeks old, after a severe coryza, the baby being infected by a sister three years old, who escaped any sequelæ. Again, who can disprove the statement in the case of the child from whom the muscle emulsion was made; that the staphylococcus was not the cause, when, to the natural muscle instability of the growing child, we have added summer heat. We must also admit the fact that children under twelve months are not frequently affected, and thus raise the question whether the cause is not dietetic. As a matter of fact, at the time of its height in certain parts of Victoria, the development in connection with wheat of Ethestia elutella was noticed, supposed to have been introduced from the Argentine, but enquiries there elicited no definite information of its prevalence, nor did experiments with monkeys and young dogs show anything definite. A food infection might explain why, *e.g.*, certain farms in a district have had cases, and yet an adjacent town escape, as I have known occur. After all, we treat a paralysis to secure, if possible, resumption of muscle function, the capabilities of which in *homo sapiens* we recognise must be vast. But the acquisition of power here, as everywhere, is not sudden. Hence, we must imitate nature, recognise that the muscle is disabled, and that to acquire a maxi-

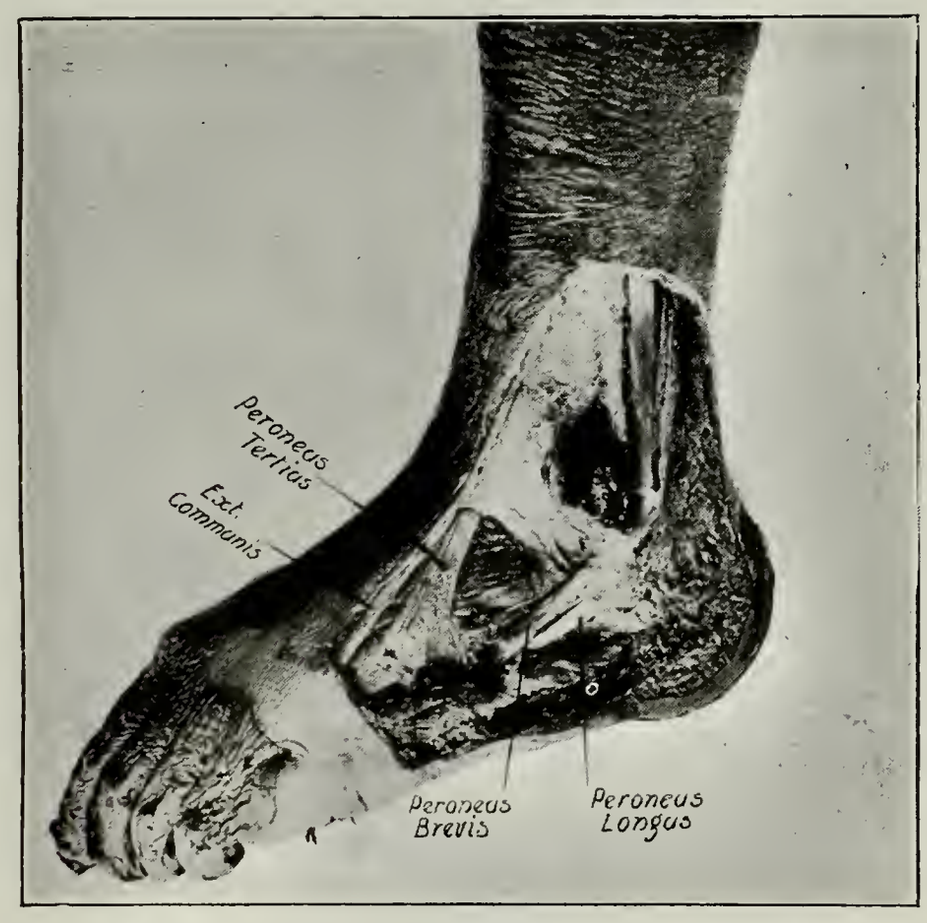
mum function we must be satisfied at first with a minimum. In the patient with hanging leg, due to a paralysed quadriceps, before performing knee excision, arthrodesis, tenodesis, tendon or nerve grafting, see the effects of the imitation of nature, by the encouragement of voluntary muscular movement within functional limitations.

The importance of the foregoing considerations in cases of muscles affected from injury to nerves can, I think, scarcely be overestimated, and in advising its use as a routine in cases of facial paralysis after mastoid operations, the question arises whether division of the facial nerve is really fatal to muscular action. That it should serve as the basis in nerve anastomosis is certain, and to me nothing seems more unscientific than to expect that in cases of Duchenne's or Erb's paralysis nerve impulses, as the result of operation on the brachial plexus, "with massage and resistive movements," will set them operating when they are asked to work at the maximum; for be it remembered in experiment that a dog's muscular system is vastly different and vastly inferior to that of a man's as regards functional possibilities. Furthermore, I am convinced that many cases of Duchenne's, if treated in this way from the outset, would recover without nerve anastomosis. Lack of this principle is undoubtedly the cause of such frequent failure after operation on the brachial plexus, and only recently recovery was obtained in an upper limb on which nerve anastomosis had been performed 2½ years previously, and also on a baby considered unsuitable, from its apparent hopelessness for operation. This question it is hoped to deal with in some future communication.

May I, in closing these principles of treatment, be permitted to point out what an interesting field a case of infantile paralysis really is. What better subject could we find on which to study the development of muscular function, and of what teeming interest to the student of anatomy in the study of the action of muscles, apart from such questions as independence of muscular action or muscular or nervous regeneration?

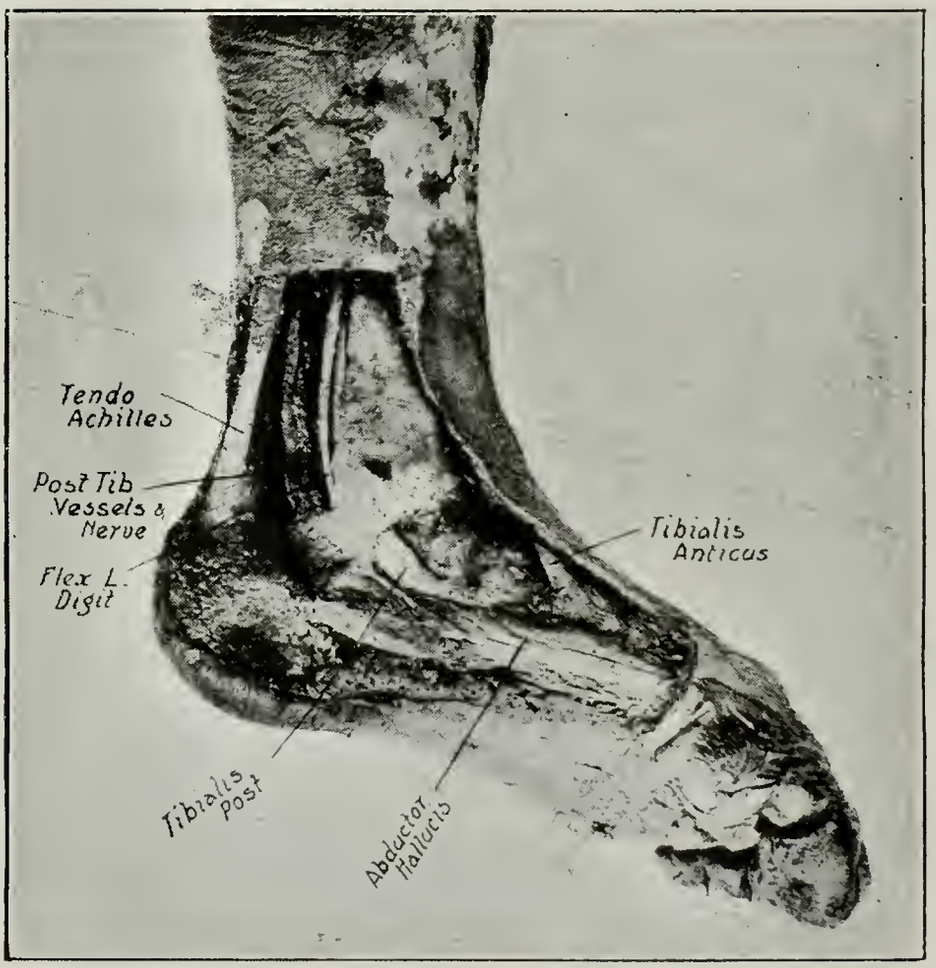
TREATMENT OF PARALYSIS OF THE LOWER EXTREMITY.

The rapidity in recovery of cases treated soon after the onset of the paralysis is slower in the lower than in the upper limb, and naturally owing, I apprehend, chiefly to lack of concentration on muscular function in younger than in older patients. Man having attained to the erect position, it became unnecessary for the upper limb to take part in the support of the body. The weight of the body fell on the lower limbs, so



that not only was it necessary for them to maintain the original support, but the added ones also from the upper limbs, which thus, as it were, became trunk appendages. This factor has an important bearing always necessary to keep in mind. The mother of the affected child is in a constant state of tension to know whether her child will ultimately walk. Mere movement indicating recovery of affected muscles is not sufficient, as in the case of the upper limb—the child

is exercised too early or with insufficient support; so that not only then is it a question of muscular movement, but also of the support of superincumbent body weights, and so accounting for the yielding of the structures about the knee, but more especially about the ankle joint, so often seen. One other point must be again referred to, namely, the relatively impaired mobility of the ankle joint as compared with that of

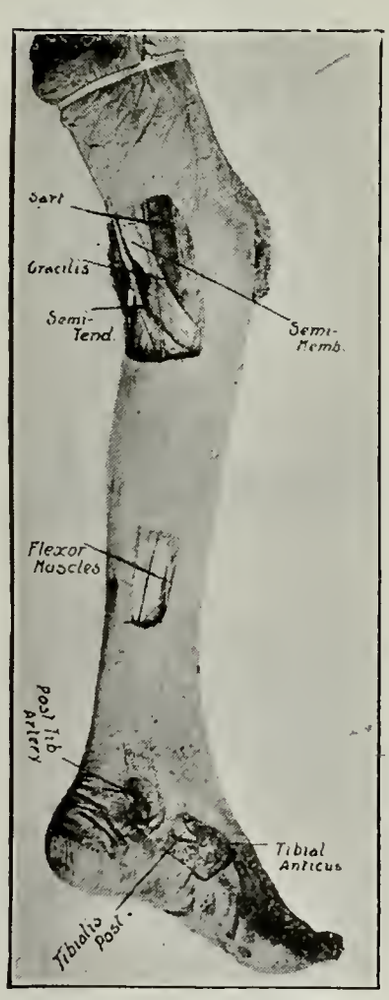


Dissection to show the Relation of Tendons at Inner and Outer Ankles.
(From the writer's Preparations in the University of Melbourne.

the wrist joint. This factor has an important bearing on the action of muscles, since these, having their origin and insertion at a right angle, owing to the falling of the heel to broaden the base for standing there is produced, that difficulty in the initiation of function, as compared with muscles having their origin and insertion in a straight line.

In the past, much of the failure of treatment of the lower limb has been the lack of recognition of the all-

importance of the quadriceps extension of the knee. We may have our five flexor muscles, but if the extensor tendon of the leg be useless, the patient is unable to stand. The hip joint is well surrounded by bunches of muscle, some of which, even in the oldest and most extreme cases, will be sufficient to give the necessary swing from the hip, provided there be no solution of continuity at the knee joint. We may have our five flexors active—the capsule and its ligaments intact, as well as the two crucial bands, and yet without a quadriceps be unable to maintain the erect position.



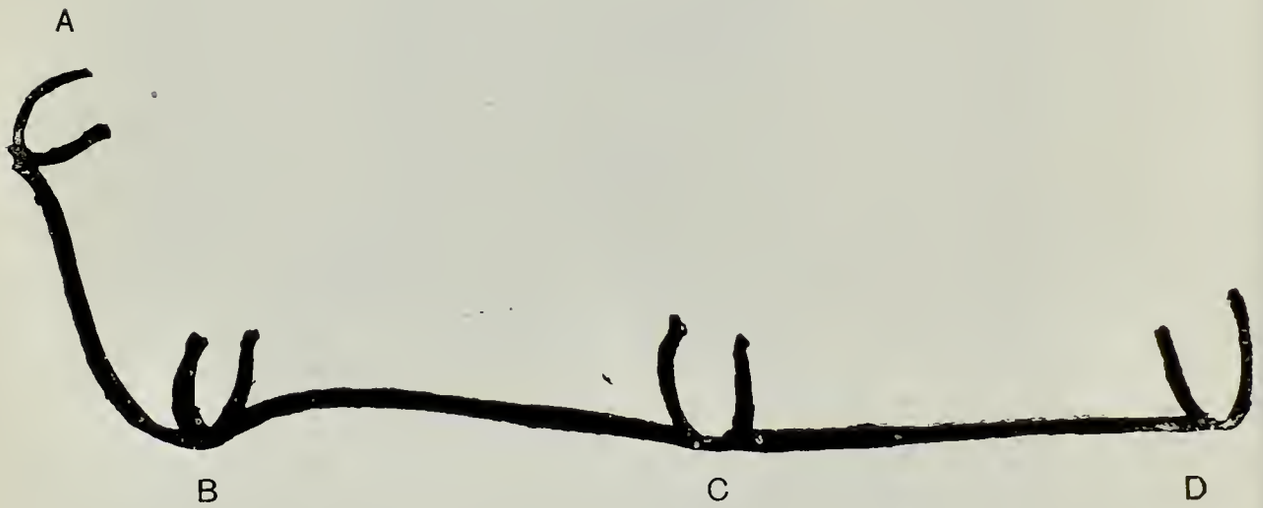
Dissection of the Inner Side of the Knee.

(From the writer's Preparation in the University of Melbourne.)

Speaking generally, for a case of paralysis of the lower limb seen early there can only be one line of treatment, namely, placing the limb in a position in

which we take the weight off the psoas muscle—place the quadriceps in the zero position of knee extension, and take strain off the extensors of the foot by placing the foot at a right angle, for these are the muscles that in advanced cases are invariably at fault. Formerly I was in the habit of using the extended crab ankle splint, dispensing with the leg plate, bringing the bar up to the buttock fold, and adding wings at the knee and upper end.

Such a splint is light, easily made, inexpensive, and infinitely superior to any form of wooden splint. To make a bed for the heel, and so obviate pressure sores, the stem may be split and shaped at that position.

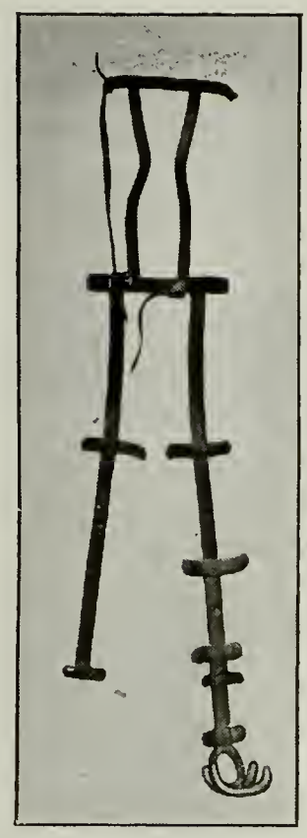


A Wing for Ball of Toes.
B Wing for Ankle.
C Around Knee.
D Wing for Upper Thigh.

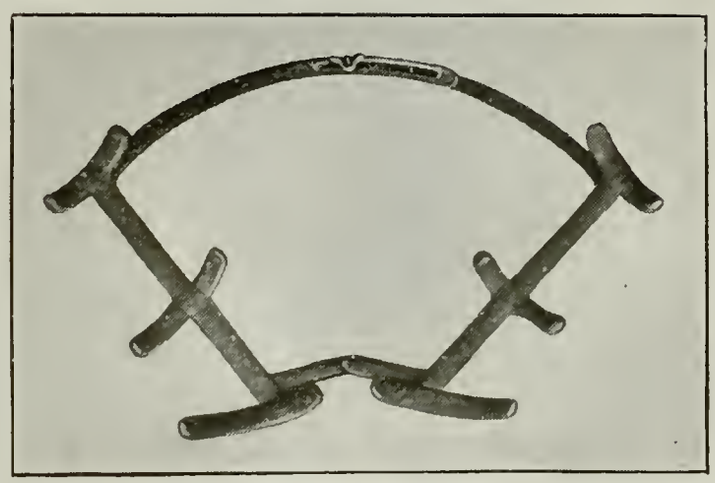
The limb may be bandaged to the splint or kept in position by means of strap and buckle attached to each wing.

The use of this splint at the outset, although convinced that its advent meant a distinct advance on previous treatment, the writer has given up for varied reasons. It gives no control over inversion or eversion of the foot, nor does it control pelvic tilting, with apparent lengthening or shortening of the extremity, nor rolling out of the thigh.

At the outset, I prefer to use, even with one limb affected—I might even go further, and say even with



one leg affected—a double hip splint, or the simpler frame here shown, and which is described in detail later. To this splint arc shoes for the feet may be attached.



Only in this way are we able to anticipate and prevent pelvic tilting due to paralysis of the abdominal parietes, and only in this way can we prevent the undue rotation of the hip, either external or internal.

and especially the former, for which there is so great a tendency.

The question naturally arises: How long is the patient to remain in the frame? That will, of course, depend on whether there is abdominal wall paralysis, and also whether both limbs are affected; and if only one, whether marked rotation, especially the external, be present.

If the former be present, then till the abdominal paralysis has recovered, which in my experience it always does. Having then satisfied ourselves that the patient can flex the thigh without undue external rotation or adduction, and that pelvic tilting is absent, then we may utilise the stems and foot pieces separately, and later, having satisfied ourselves about the knee muscles, only the foot pieces, the leg muscles being in my experience the slowest to recover.

As a minimum in any affection of the lower limbs, I would say six weeks for the frame or double Thomas. In the case of two sisters from Bendigo—one 1½ years old and the other 3½ years—with in each case both lower limbs completely affected, the younger was kept on the frame twenty-three weeks, and the elder for six weeks. Both are able to walk unsupported.

The writer's Arc Foot Splint.

The arc foot splint is made of tin in two pieces, soldered together at the heel—one for the foot and one for the leg, extending to the junction of the middle and upper third. For the avoidance of pressure, the

leg piece is opened at the heel. In measuring for this splint it is best to take a tracing of the leg and foot on cardboard, but at an angle for the foot piece.

The sole of the foot not merely rests against the foot piece, but the edges are turned up for one inch on the inside, and three-quarters of an inch on the outside, thus forming lateral shields to keep the foot in position.

The leg piece really follows the contour of the leg, and is open on the anterior face.

The circumferences of the ball of the foot, ankle joint and calf of leg should be noticed.

The splint may be attached by means of a bandage, or preferably by means of buckle and webbing straps,

The writer's Extended Arc Splint.

as in the illustration. At the ankle the webbing is applied in such a way that direct traction is applied over the joint. The splint is lined with blanket, and covered with chamois, the edges being turned slightly out.

The extension to the upper third of the thigh is made by means of a stem of malleable iron, 5/8 by 1/8.

Two wings are attached by means of a rivet—one at the knee joint and one opposite the upper extremity

of the splint. The stem, as well as the wings, are similarly padded with blanket and covered with chamois.

To avoid the tendency to in-knee, a stem of light malleable iron or aluminium may be applied, with the convexity out from the leg to the thigh wings, towards which the convexity of the knee is pulled either by means of a bandage or a strap.

The writer's Splint for Preventing In-Knee.

In connection with the application of splints in this disease, which many seem to think constitutes the treatment, instead of being merely a means to an end, certain points are essential for success:—

(1) The muscles are immediately placed in a position where they begin work from zero, which really means that origin and insertion are as nearly as possible on a level and in a straight line.

(2) Bandages should not be too tightly applied—are best of flannel—and the limb should be well surrounded with wool.

(3) For the first week, prefer full extension of the knee, but later a pad should be placed under the joint to relax it, and so avoid the tendency to hyperextension, which may be present when the child commences to walk.

(4) As so much of the success depends on early treatment, it is essential that the person in charge of the case be fully seized of the main points in treatment, is enthusiastic, and prepared for self-sacrifice.

(5) Splints must be accurately fitting. A badly fitting splint, *i.e.*, one allowing a strong set of muscles to drag on a weaker is a handmaiden to deformity.

(6) Once treatment is begun, the maintenance of position must be rigidly enforced, the mother being

A Patient in whom Hyperextension of the Left Knee has been allowed to occur.

taught how to hold the affected parts when taken out of the splints, and similarly with massage. Failure here renders the whole treatment farcical. When recovery is taking place I never allow kicking in bed with the splint off unless flexion and extension are regulated. One frequently sees the child when out of the splint acutely flexing the limb or dangling it over the sides of the table, and similarly with a splint that corrects flexion of the foot, but not eversion or

inversion. " Mit der Dummheit kämpfen Götter selbst vergebens."

(7) In the case of the muscles about the ankle, recovery is apt to be unsatisfactory in many cases, nor is the cause hard to seek. Splints are not fitted properly, and mothers take the patient out of the splints and dangle them on a chair, or commence them walking, with the result that weak pivots are asked to support the body weight, and yielding of the ligaments results.

In connection with the muscles of the feet, where I am suspicious of maternal laxity, it is better to use plaster of paris, leaving the dorsum or inner or outer sides open, so as to encourage movement of the weakened muscles.

During this time no massage is advisable, since its use is recognised, not in restoring muscular function, but in strengthening it when restored; but encouragement of voluntary movements within functional limitations is advised, for to expect relaxed muscles to recover is erroneous, since relaxation simply means placing the muscles in the zero position, from which all muscular action should commence. This may generally be commenced at the end of a week, though in cases of double paralysis, with abdominal affection later. That the muscle should be encouraged to work, and not be irritated by massage—for it certainly is neither doing the work for the muscle nor encouraging it to work, I regard as the basic part of the treatment. Tact and patience, of course, are required—the more so the younger the patient. A warm room, broad table, with a blanket drawn tight, and absence of friends are working essentials. In the performance of these movements attention should be concentrated on an affected quadriceps.

At an early stage, and, indeed, for some time, there may be absence of or slight toe movement. Nevertheless this is best encouraged by supporting the ankle with the knee extended, and blowing or tickling the foot and numerous other devices. Again, around the hip joint we have powerful muscular masses, and my experience is that, provided we have repose for these, and especially prevent hanging of the limb and the

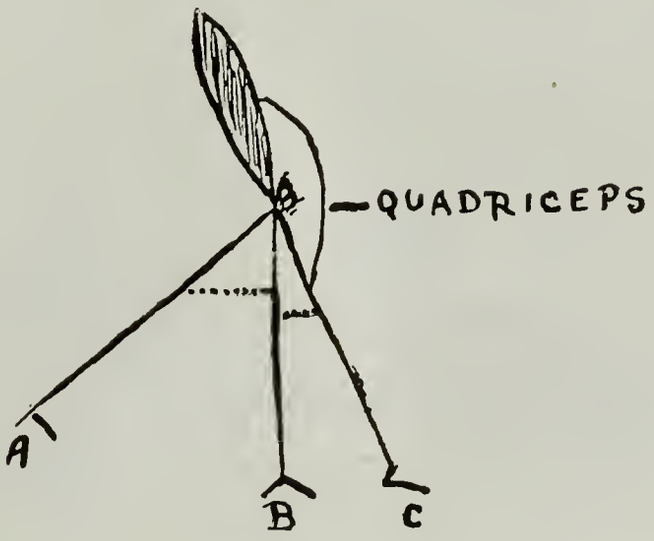
tendency to eversion, we will have little trouble about that joint.

If we take a lower limb with a quadriceps that has been paralysed for some time, on flexing the knee with the patient reclining, and taking away any support, the limb still flexed falls usually in the abducted

To illustrate the Falling Out of the Limb, with a Completely-paralysed Quadriceps.

position, for if there be no quadriceps power, not merely the weight of the limb will be sufficient to straighten the knee. On flexing the knee for, say, one inch, it may be noticed that the limb falls straight, or, if bent, say, three inches, the patient may be unable to straighten the knee, but can prevent it falling out —that to me is evidence of commencing recovery.

Week after week the flexion is increased, the fall being gradually replaced by a definite push, till finally



the patient, holding the knee in the position of acute flexion, without adduction or abduction of the thigh,

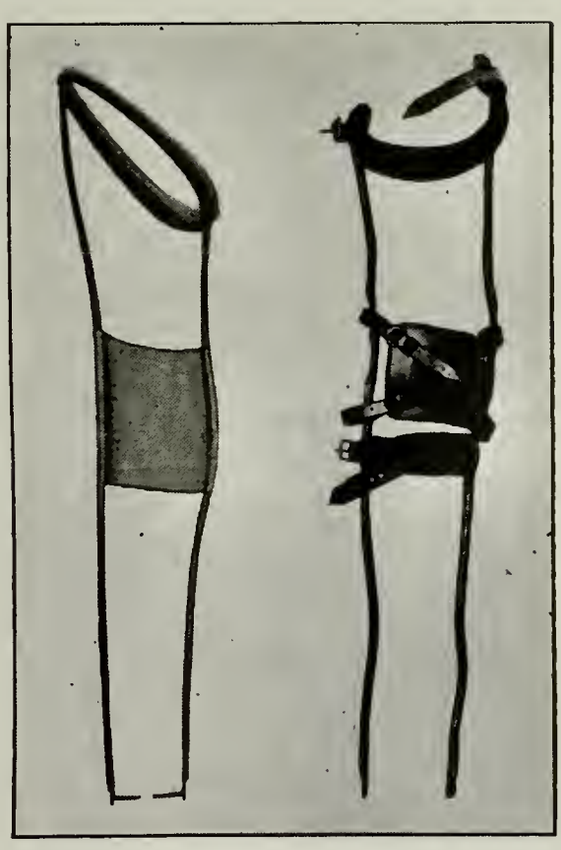
is able to straighten the limb. But such a limb is not yet able to bear half the body weight. Our ideal recovery is where the patient is able to raise the heel off the ground, with the knee extended.

To illustrate the Ideal Recovery of the Quadriceps.

Even with this amount of power present, this latter is usually impossible, and here again the principle of gradual acquisition of muscular power comes into play; and so if we alter the leverage by turning the

Patient unable to raise Limb extended when lying on the back, but can when turned to opposite side.

patient to the opposite side, usually we find he will lift the limb in one piece. Then gradually, week after week, by means of a pillow, the body tilt is altered, till finally the supine position is reached. At this stage much assistance may be given—where one limb only is affected—by flexing the thigh and knee on the sound side, with the foot flat on the table. In this way the pelvis is steadied, and thus considerable assistance is given to the perfection of the limb elevation. Then, and then only, is our patient ready for walking, which may be allowed in spite of the absence of recovery of the foot muscles, provided there be no deformity, and that the ankle be supported by stiffening the sides of the boot or other means.



The writer's Lower Limb Splint, and the Hollow Tubular Steel Caliper Splint.

Even yet it is a mistake to allow our patient to walk, for if the knee be unsupported the tendency is to acquire balance either by everting the limb or hyperextending the knee, or both. Hence, I prefer the use of a splint, in which movement is obtained from the hip joint, and the knee is rested in the ex-

tended position. This may be secured by the splint here shown.

This splint is made of hollow tubular steel, with, in young children, a diameter of 4-16, and in older patients 3/8. The ends of the splint are flattened to allow of a light quarter bolt passing through the heel of the boot, as well as the ends of the splint. Into the heel of the boot we have a steel tube fixed, which is usually placed obliquely, according to whether inversion or eversion be present. Though formerly we used four wings, which were also hinged at the back, we now prefer only two—one at top, the upper edge of which is bent back and well padded to prevent rubbing of buttock; and one at the upper third of the leg.

These bands are made of sheet steel, 5/8 x 1-16, and covered with black velvet, surmounted with black leather. At the knee is an ordinary box joint—the angle of flexion of which, by means of a pin, may be variously altered. As a rule the splint is set at the outset in the position for complete extension of the knee. If hyperextension be present the position of fullest extension allowed may be that with slight flexion. As the strength of the quadriceps improves, more and more flexion may be allowed at the joint, till finally full flexion is reached. The lateral stems are uncovered. The splint is applied by means of straps and buckles. Flexion of the knee may be prevented by a bandage or a square leather knee piece hollowed out for the patelle. In cases of in-knee, this may be corrected by means of a heart-shaped leather piece, the traction being made to two studs on the outer stem. In young children, *e.g.*, under four, owing to the support the ring gives to the trunk, I prefer the caliper pattern of the tubercular knee splint, reverting to the above splint later.

This splint, like the preceding, has its lateral stems made of hollow steel tubing. It is hardly necessary to emphasise the importance of lightness in connection with splint construction for cases of paralysis. Surely the affected limb has sufficient work to do without making what should be merely accessory to move-

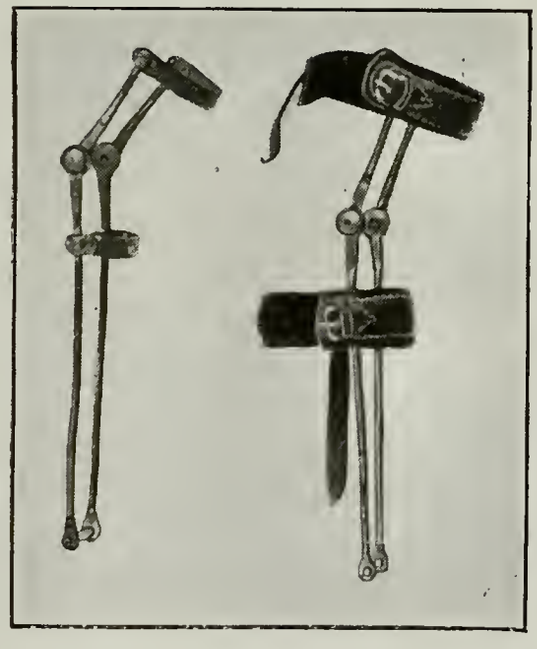
ment also burdensome. The hollow pattern for a child of twelve years need only weigh 1 lb.; yet the solid splint for the same age scales three and a quarter times the weight.

In this splint, as well as the preceding, it is best to have the shape of the splint following the contour of the limb. This is effected by taking a tracing of the limb on a piece of cardboard.

Hyperextension of Knee and Eversion.

We may see a patient able to lift the limb with slight inversion or eversion, and who yet, on standing, will allow the knee to become hyperextended.

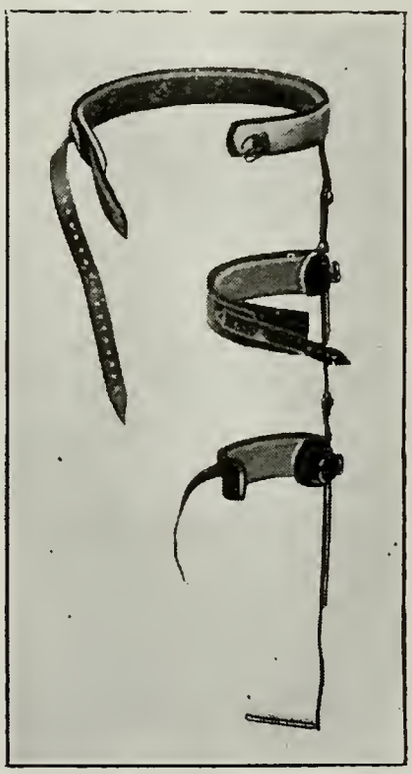
This is readily overcome by having a flexion pad under the knee at night, and indeed, as previously mentioned, it is advisable, after the first week, to have a slight flexion at the knee; and in the daytime, having the splint so bent that the position allowed for greatest extension at the knee is really slight flexion.



Showing how the writer's Lower Limb Splint may be fixed to overcome Hyperextension of the Knee.

The tendency to eversion of the limb may be overcome by having the bolt through the heel of the boot

in the leg splint obliquely placed, but it is best overcome by means of the pelvic band splint here shown. This is a splint designed to correct inversion or eversion of the lower extremity, and may be used also to correct hyperextension of the knee. It consists of a lateral spring steel band forged with lugs and slides to allow for extension as the child grows, and thus, to save further expense, an important factor amongst



Splint to correct Inversion or Eversion of the Lower Extremity.

the poor. There are three wings—pelvic, thigh, and leg. The pelvic band, which does not extend right round the pelvis, is made of mild steel, ¾ x 1-16, padded with blanket and surmounted by velvet and webbing. It is riveted to the top of the stem.

Corresponding to the hip joint is a plain lap joint, the angle of which may be allowed to vary. There is also a similar joint opposite the knee, the angle of flexion of which may be regulated by means of a pin. The knee and leg wings are also made of mild steel, ⅝ x 1-16, and are also riveted to the stem.

The stem is uncovered. The end of the stem is fixed into the heel of the boot by an L-shaped steel

pin. Inversion or eversion may be controlled from the piece of stem adjoining the pelvic band by setting either backwards or forwards by means of wrenches. No bandaging is necessary, the wings being fastened by buckles and straps of leather or webbing. If overextension be present at the knee, a band can be attached to the two lower wings on the inside, and the splint set in the position of slight flexion.

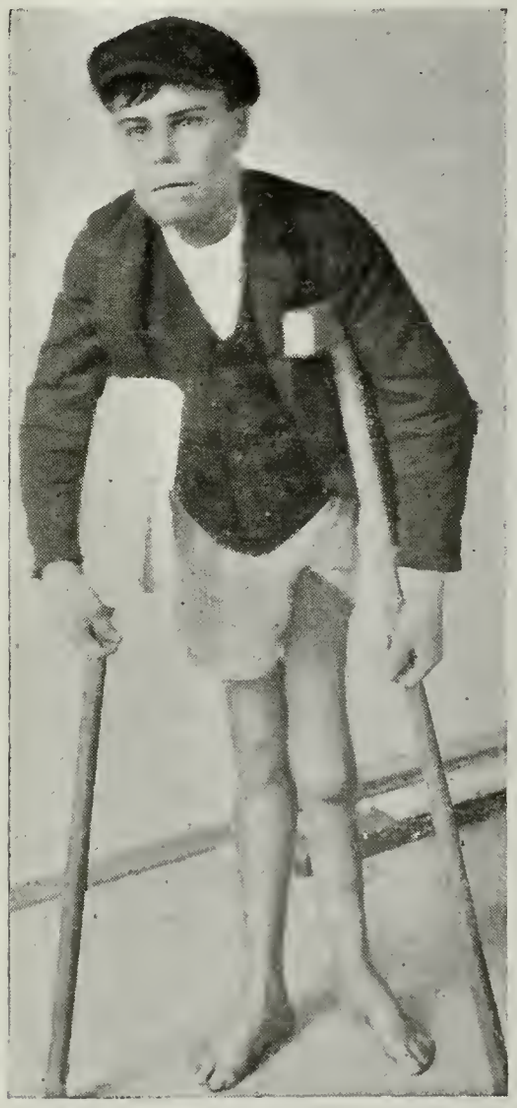
As regards the foot muscles, we have stated that a child may be allowed to walk before the recovery of these, provided the ankle is well supported, that no deformity is present, and is kept in the arc foot splint at night. Any yielding of the joint producing a tendency to either in-ankle or out-ankle may be corrected by an ankle-strap—if in-ankle with everted foot from the inner ankle to outer stem, and if out-ankle from outer side of boot to the inner stem—the side of the boot which should reach well up the leg being stiffened, and the sole raised on the inside or outside as necessary.

Unfortunately, there are a large number of hospital patients for whom muscular action and rest can never be insisted on, and who are regarded as hopeless. They are to be met with ambulating with crutches, or shackled with expensive and often useless instruments. As a typical example of the class, this patient may be cited from the Melbourne Children's Hospital.

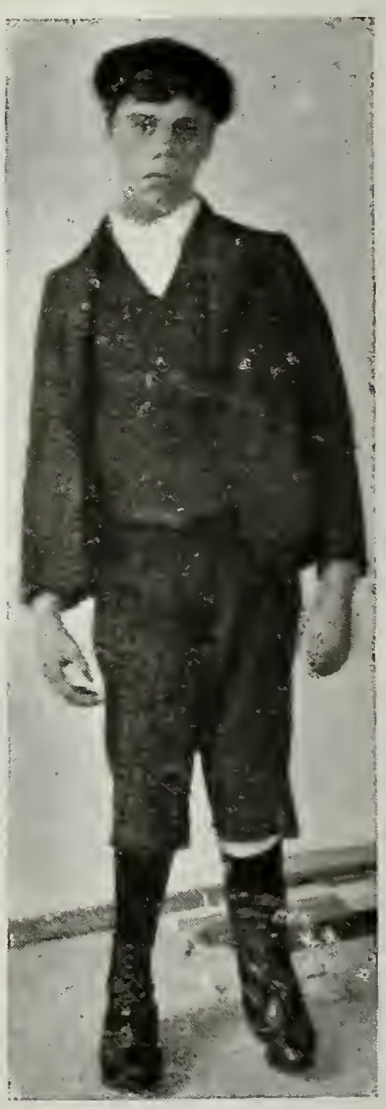
A boy, æt. 14½ years, who has never ambulated without crutches, infantile paralysis having attacked him early in life. He has one sound limb—the other merely a reddish-blue hanging appendage; and a more hopeless case one could not expect to meet. Everything in the way of treatment, such as massage and electricity, had been tried.

On examination, there was paralysis of the muscles of the leg and quadriceps, and an inverted foot—slight action of the hamstrings with the thigh adducted. He could jerk his thigh on to the abdomen from the abducted position; in other words, a patient with little

psoas, no quadriceps, and no leg muscles. On stiffening the knee with a book and bandage that were at hand, we found he could slightly swing his limb, and at once prognosed that he could walk. All we wanted was something to concentrate what muscular action was left at the hip, and at the same time to keep the knee immobile, the condition of the foot not



The Patient mentioned in the text.



Able to Walk one week later.

bothering us as long as it was mobile enough to go into a boot. With a caliper splint, and having no lordosis, our patient started walking at once—at first with a stick, and later, without support, and such a result we get even with both limbs affected.

In further illustration of this principle, the following examples of cases before and after treatment may be cited:—

A

A

B

B

C

C

A. Never walked; paralysis of both lower limbs; no quadriceps; no contractures; little hip flexion. On applying splints, at once got about with crutches; a week later, could walk well without support, but with splints.

B. Eight and half years' standing. Poor psoas, no quadriceps, and leg affection, with contracture. In three weeks could walk half-a-mile without support, but with the caliper splint.

C. Nine years' standing; poor development; some pelvic tilting present. On applying caliper splint could walk up and down room.

Thus, by the use of a simple mechanical device and a recognition of an anatomical principle, namely, the importance of knee extension, it is possible to convert a pitiable object into an asset to the community without operation and at a cost almost infinitesimal.

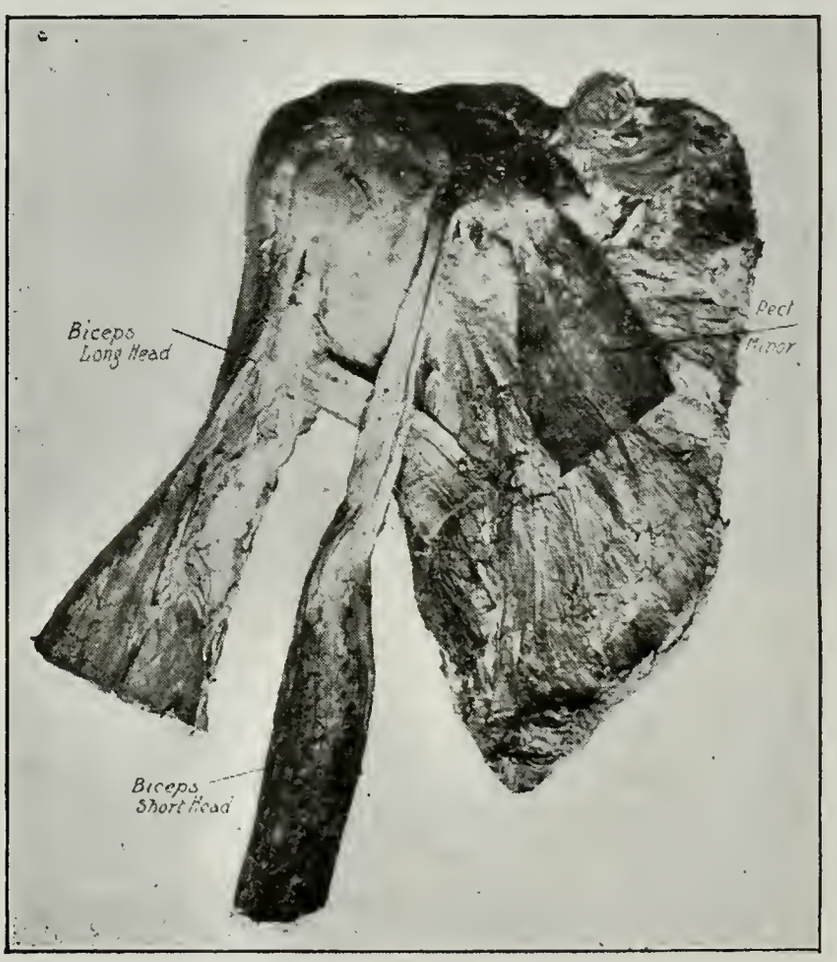
THE

IMMEDIATE TREATMENT OF INFANTILE PARALYSIS OF UPPER LIMB.

Epidemics of paralysis, from the therapeutic point of view, can only be of value where some systematic method of treatment is decided on, and thus a comparison may be instituted with results obtained from previous treatment. Admittedly, upper limb results in infantile paralysis have not been good, and the surgical treatment is much more unsatisfactory than in the lower limb, the chief procedures being arthrodesis of the shoulder, shortening of tendons on the back of the wrist, and skin excisions to bring arm and forearm in apposition where the hand is useful, since tendon transplantation in the upper limb is frequently without result. In this chapter an endeavour will be made to show the benefits of immediate and absolute rest in this condition, and the method by which this is ensured.

As has been previously pointed out, a muscle is rested only when it is placed in a position where its work is zero, and its origin and insertion are as nearly as possible on a level, since the resumption of function (which should be gradual) is always easiest along a straight line. This is well exemplified in the case of the deltoid and biceps muscles, which, with the quadriceps, may be truly said to represent the "*furchtbarkeit*" of infantile paralysis. The function of the deltoid being to raise the arm from the side to a right angle, its zero position would be represented by the latter. In that position, it is maintained by means of the upper limb splint here shown, and it is coaxed into action, not by removing the splint and allowing the limb to drop, but by gradually altering the angle both of body posture and of limb, such

alteration being *pari passu* with the amount of recovery present; and similarly, the biceps is not rested by mere flexion, for the long head crossing the shoulder-joint is still overstretched, and not only should we have flexion of the forearm, but the arm should be raised, as in the deltoid cases—in other words, to speak of relaxing a biceps by means of a sling, *i.e.*, by merely flexing the forearm, is anatomically unsound.

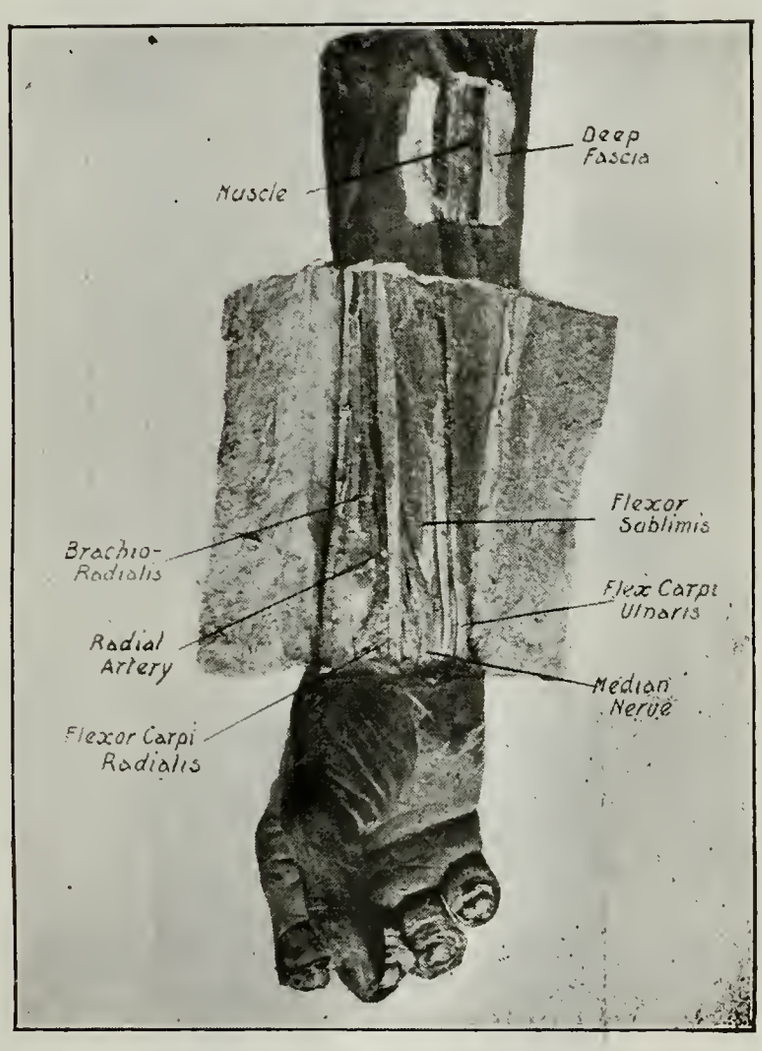


Dissection to show the Relations of the Biceps at the Shoulder

(From the writer's Preparation in the University of Melbourne.)

The upper limb splint is founded on distinctly anatomical principles, which ensure muscular rest and allow of the commencement of the resumption of work for affected muscles from zero. Support is ob-

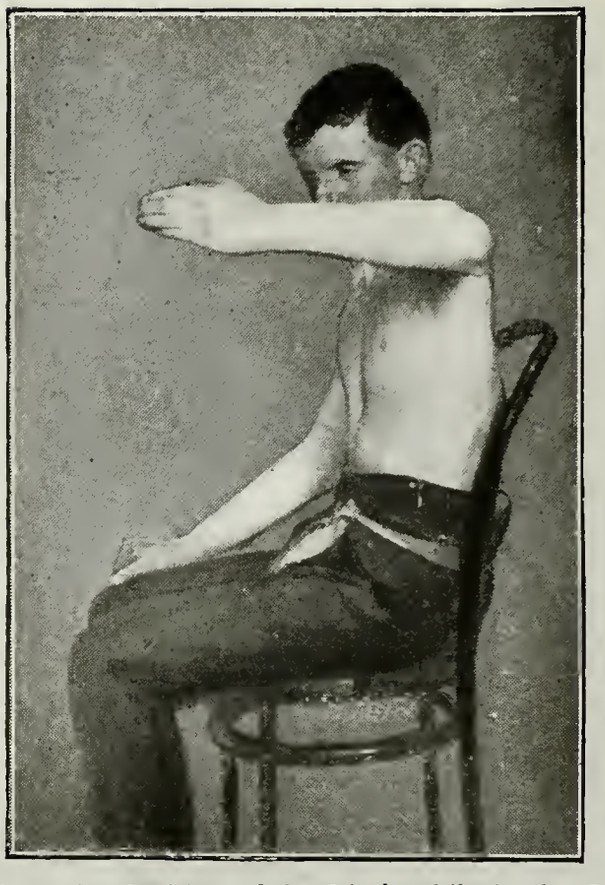
tained by means of wings round the thorax. The arm is abducted for the deltoid, as well as for the long head of the biceps. The elbow is slightly flexed; the forearm placed midway between pronation and



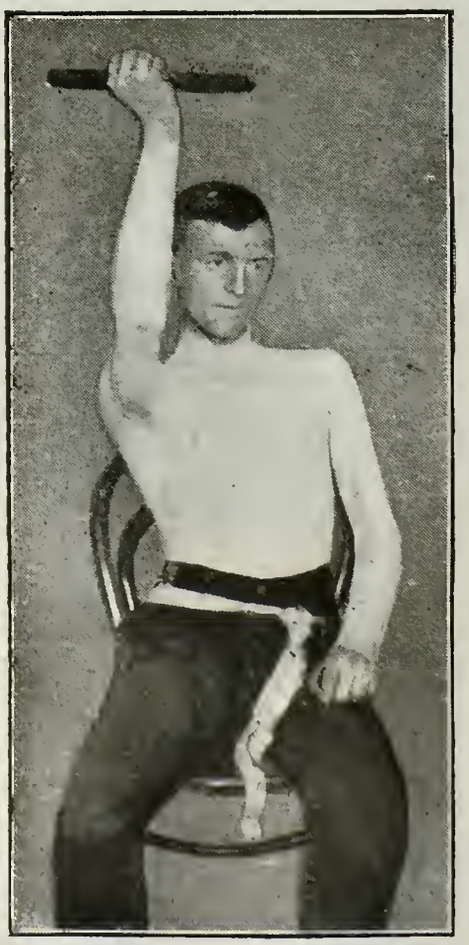
Dissection of Tendons in Front of Wrist.

(From writer's Preparation in the University of Melbourne.)

supination, with extension of the wrist and slight flexion of the fingers. To place the hand in the position of over-pronation, as is so often advised, is undoubtedly wrong, and for two reasons:—Firstly, a gymnast secures the greatest strength of the upper limb in the position of over-supination—in other words, the biceps is strongest in that position which means that a weakened biceps thus functionises most



To show the Position of the Limb while in the Splint.



To Illustrate the Position of the Upper Limb for a Strong Grip.

easily, and function should be commenced in the position which the limb has occupied on the splint; secondly, there is the great danger of recovery in over-pronation, which, in spite of good biceps, good del-

An old case of Upper Limb Paralysis with an Irreducible Over-Pronation.

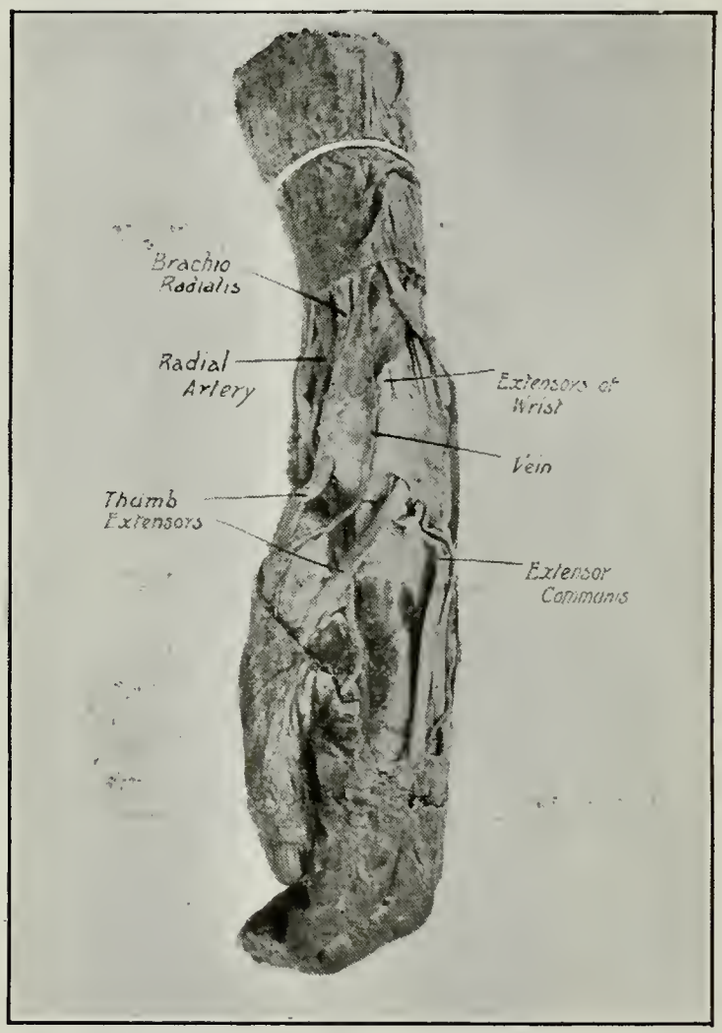
toid, and good finger action, may suffice to ruin the usefulness of the upper limb, since, *e.g.*, feeding depends on over-supination.

It is scarcely necessary to point out the simplicity of the principle of this splint, and it certainly gives a true and effective rest to the shoulder, such as could never be secured by means of strapping the humerus to the side, and supporting the forearm in a sling. The support of the splint is derived from the trunk, the limb merely resting on a support designed to give it correct anatomical rest.

The basis of the splint is a stem made of ½-inch malleable iron by ⅛.

It runs up in the mid-axillary line, extending as far down as the costal edge, following the contour of the under surface of the arm and forearm, being bent to the requisite angle at the top of the axille and at the elbow.

If necessary, a hinge may be attached corresponding to the elbow joint, but this is usually not necessary.



Dissection of the Radial Side and Back of the Wrist.

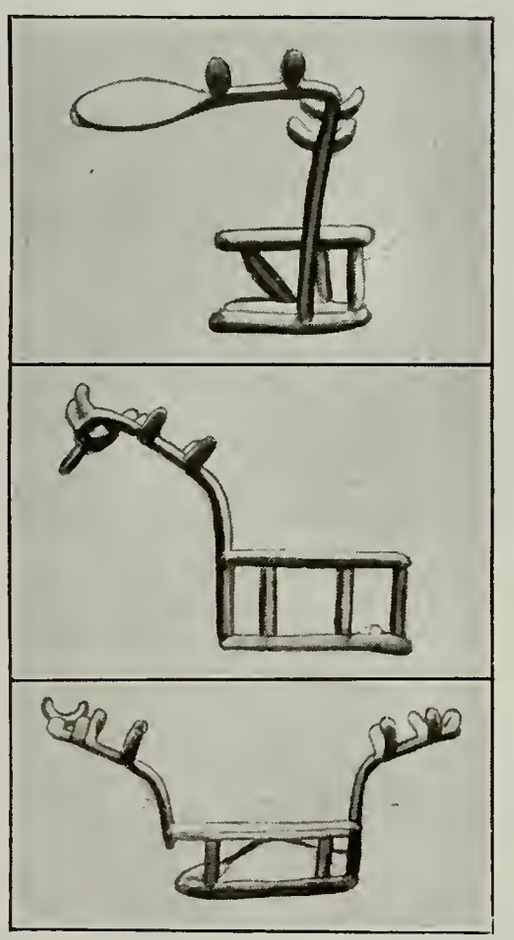
(From the writer's Preparation in the University of Melbourne.

In measuring the patient for the splint, it is best to take a tracing of the arm and forearm on a piece of cardboard, as shown in the illustration, taking a tracing of the hand separately. Only in this way is accuracy to be attained. The contour of the side of the thorax is supplied by means of a tracing with a strip of lead.

The circumferences of the wrist, elbow joint, shoulder, and of the thorax are taken.

The wings for maintaining the limb in position are made of mild steel, ½ inch by 1-16 inch, and are placed on the upper surface of the stem in the following position, namely, at wrist joint, elbow, shoulder, and two which extend about two-thirds round the chest, being connected by means of a strap and buckle. The remaining wings are not connected by a strap and buckle.

The hand piece is made of tin, slightly hollowed for the ball of the thumb.



The writer's Upper Limb Splint, showing the Side and Back View.

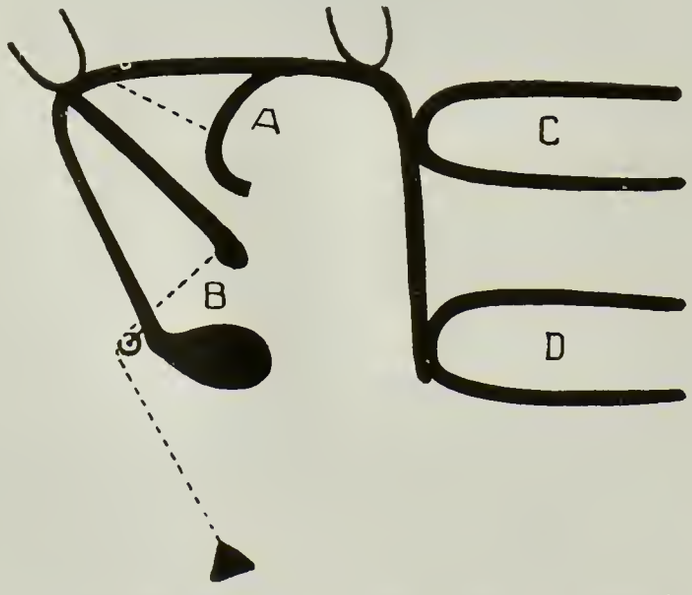
The limb, well padded with cotton wool, is held in position by means of a bandage. As a rule a bandage round the chest wings is unnecessary.

To keep the splint well against the axilla, nothing is so useful as the ordinary linen bib. To the lower edges of this, in the front and back, two pieces of webbing are attached, which pass round the upper wing of the thorax, and are fastened to a button.

Where both upper limbs are affected, a double splint may be applied, the chest stems being hinged posteriorally to allow of ease of application.

Showing the Front and Back View of the writer's Double Upper Limb Splint. The Method of Attachment is also shown.

It may be mentioned that the uses of the splint are not merely confined to cases of infantile paralysis. It may be utilised in a number of upper limb conditions, and at the Rizzoli exhibition, held at Bologna, Italy, last year, its application was shown in at least fourteen varied conditions.



To illustrate some Uses of the Splint in Overcoming Contractures of the Upper Extremity.

In testing for muscular power, this should be done with the patient lying down, and the affected limb resting on a pillow in the same position as when in the splint, and it is surprising, when tested in this way, what a large amount of power a biceps may show which we previously regarded as functionless.

To illustrate the poor attempt at Elevating the Upper Limb when sitting up, although there is Complete Recovery when Reclining.

Then, again, with the patient lying down, we may have good deltoid and biceps function, but sit the child up, and the amount of movement is much less obviously, since the leverage is greater, so that not only have we to coax our muscle to functionise with the limb in the easiest position, but similarly with the position of the limb relative to the rest of the body.

It is absurd to test a child with weak deltoid and biceps for the first time sitting upright. Commence in the reclining position, then gradually raise the body by means of pillows to the point beyond which effort becomes manifest, and so finally we arrive at the upright position.

It was on these lines that I resolved to treat all the cases seen within a period of twelve months. I saw during that time in all twenty-two upper limbs, and the results may be considered under three classes.

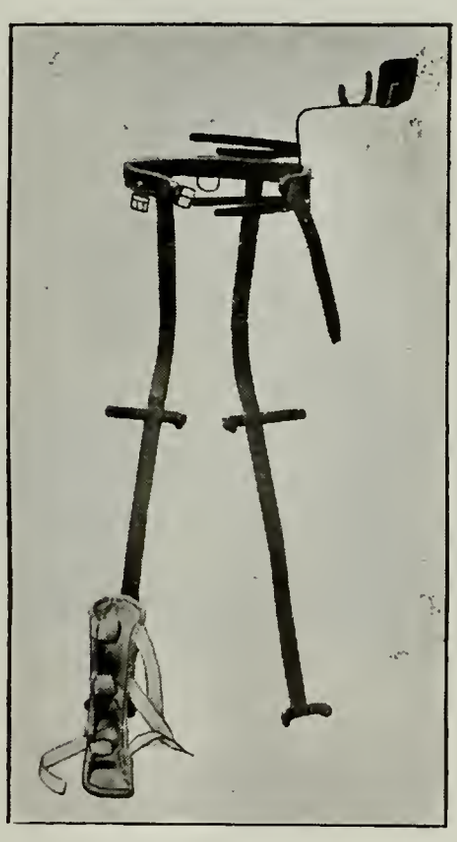
CLASS I.

This represents case treated within ten days of the onset of the illness, and corresponds to ten upper limbs. They were all cases of deltoids, extensors, biceps and supination affection, and all were immobiled without massage for from ten to fourteen weeks, and of these nine recovered. They were not cases that would have recovered spontaneously, for in the writer's experience the spontaneous cases rarely last more

than one week, but in these the improvement in condition was gradual. The case that did badly was that of a child with four limbs and the muscles of back and neck with marked meningeel symptoms. The other limbs have recovered, but the right arm, though improved, is, as regards the hands, still unsatisfactory, though hopeful, the mother having resumed treatment after seventeen months' absence.

One of the cases of Class I., seen within five days of onset. Rested in double hip splint for the legs and double arm splints for the upper extremities. The latter were rested and exercised for a period of fourteen weeks, then splints discontinued. His limbs have completely recovered.

Within an hour after being seen, all cases were immobilised by means of the previously described splint, with, when possible, recumbency by means of a double Thomas splint. Personally, at the outset I prefer complete recumbency, with even one limb affected,



Showing how the Double Hip Splint may be modified to treat Paralysis of the Left Upper and Right Lower Extremity.

using, not owing to any particular virtue, but for its convenience, the double hip splint. The limb was well surrounded with wool, and rested completely for a week. At the end of that time, in the recumbent position, the limb was taken off the splint, and placed on a pillow in the position occupiel when, in the splint, biceps action was encouraged first, and with the forearm supported also movements of the fingers.

Deltoid action was encouraged by slightly lowering the arm from the right angle, and asking the child to raise it; also by rolling the child slightly to the opposite side and elevating the elbow off the pillow, seeing if the child could maintain it in this position. In this manner the patient was encouraged, at first once a day, and later as often as eight times, to abduct the arm from the side at first with flexed and later extended elbow, and also to raise it above the head, in addition also to flex and extend the elbow with the arm abducted, and later with the arm gradually lowered; encouraged to pronate and supinate the forearm; flex and extend the wrist, at first gripping the middle of the forearm; also encouraged to move the fingers in flexion and extension, attention being paid to abduction and adduction of the thumb. During all this time no massage was allowed. There need be no objection to its use when the movements of all the muscles are effected even in recumbency, but not before, for in these cases of paralysis massage may strengthen function when present, but how can it be expected to initiate it?

The movements of all the muscles having been satisfactorily accomplished, the same routine was gone through, with the head and trunk slightly raised by means of a pillow, and thus the upright position was gradually and finally reached—the splint being kept on for at least four weeks longer.

CLASS II.

In this division, which represents a series of five cases, I place those not rested within four weeks of the onset, the longest time being seven weeks. In all five we soon obtained a recovery in the reclining position, and in three on the splint for eighteen months, also in the upright position, and I feel certain that with patience the other two will ultimately be coaxed to functionise in the upright position.

A patient who had affection of both upper and lower limbs. Now is able to walk about unsupported, and can lift the upper limb in the almost erect position, still needing slight back support.

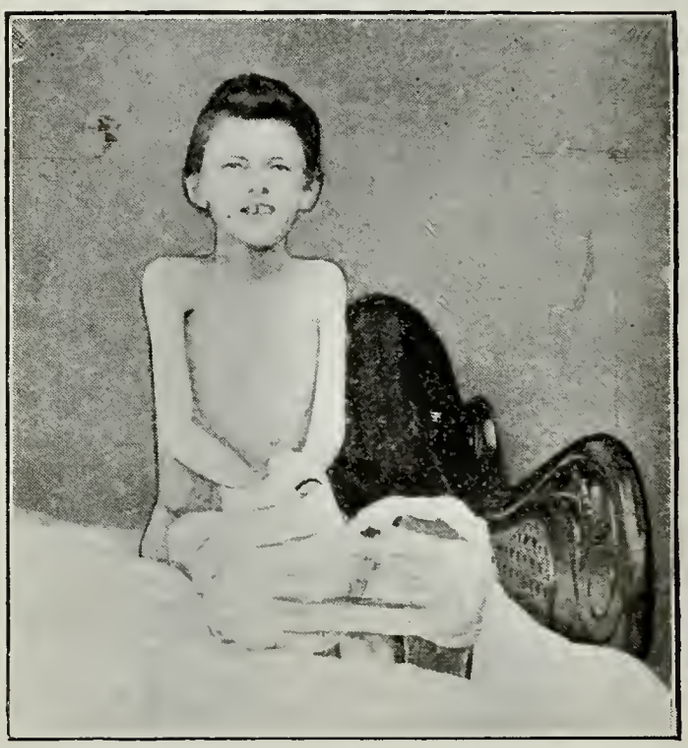
CLASS III.

In this division, representing a series of seven cases, I place those treated with electricity and massage, but no splinting or rest, and with over a three months' history. In all the affected limb or limbs hung powerless owing to paralysed deltoid.

Usually the most that can be hoped for from the splint is biceps action and improvement in the condition of the muscles of the hand and wrist. I think it is futile to expect return of deltoid function in the majority, and possibly the best to be done for these is the operation of arthrodesis of the shoulder, as

designed by Professor Vulpius, of Heidelberg, by which we get brought into play the action of accessory shoulder muscles.

Unfortunately, any improvement in the hand, and especially the thumb, is frequently hopeless, the majority of cases being unable to adduct the thumb, and so rendering useless shoulder fixation or the elbow to a right angle.



A case belonging to Class III. First seen seven years after onset. In spite of years of massage and electricity, limb hung powerless at side. As there is some biceps action, arthrodesis of shoulder has been advised.

In one case recently seen recovery has been obtained, after eighteen months, of all movements when the patient is recumbent, and this after eight weeks' rest and voluntary movement. Hence in all the cases of this class it is advisable to try the effect of the splint for at least three months, for we can certainly do no harm. This patient had had no splint, only massage from the outset, but never physiological rest.

A case belonging to Class III., with recovery of deltoid and biceps after nearly fifteen years. Over-pronation still renders the limb ineffective.

In this way I have classified my series, seen in twelve months. I endeavoured to treat all systematically, and the results coincided with what I deductively assumed they would be. The cases were not picked; they did not recover immediately, and were all known to the students attending the clinic. Above all, we could observe other cases, not so treated, to contrast with our treatment. It seems we are unable, electrically or otherwise, to estimate the recuperative power of a muscle, in the same way as we are unable to absolutely prognose whether an acute illness will be fatal or not. I have seen a quadriceps recover after many years with rest, that was considered electrically as hopeless, and that in spite of knee contracture.

The all essential thing in this treatment is that it must be immediate. To me it admits of no delay. It is a recognition of the principle that the muscle will work, but to work it must be coaxed. It is antagonistic to the principle that whips the tired horse. The muscles are immobilised as soon as seen, and not left to hang till the splints are ready, in perhaps a week's time. We would rest a fractured bone immediately,

or surgically clean a compound fracture, and why differentiate in the case of a nerve or muscle. Seeing a case in the acute stage, say with one limb affected, I would place the other three limbs in the position of repose, and candidly believe that a possible affection of these other would be slight, or not at all.

To keep a muscle at rest seems contrary to the older conceptions of treatment, *mais c'est une revolte*. Yet the splendidly nourished condition of a limb after three months' immobilisation bears witness to the treatment. Of course, all cases will not recover. We are bound, as in all diseases, to meet cases with poor resistance, especially syphilitic, or with a big poisoning, and, of course, to speak of anything as being curative is fallacious. The object of this chapter is to present the results of treatment, and the belief that, with immediate physiological rest, the necessity for mechanical or operative treatment later will be minimised, and in the majority of cases rendered unnecessary in the upper extremity.

A STUDY IN MUSCULAR FUNCTION.

The following muscular study is submitted, since I venture to assume it illustrates in no uncertain way, by means of a definite case, muscular considerations in this disease, and serves to summarise the views previously expressed.

I.—The History.

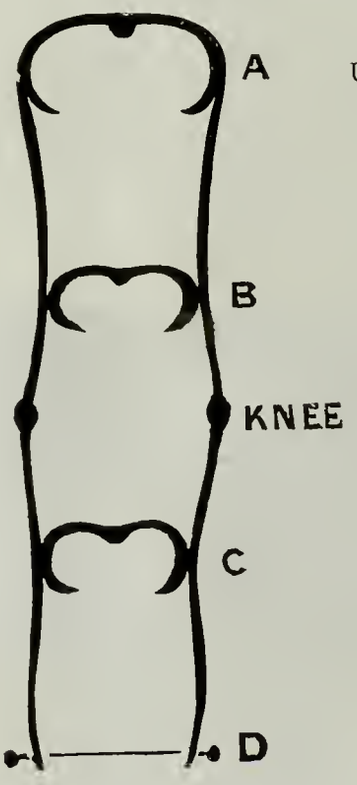
Briefly, the history of the case is as follows:—The patient, a boy eleven years of age, came to me in April, 1909, with the report that he had never walked without crutches, having been attacked with infantile paralysis when fifteen months old. Figure A gives

Figure A.

a good idea of the knee condition—to which this chapter particularly refers—with its paralysed quadriceps and over-action of flexors of the knee. Massage and electricity "to maintain muscular tone till the cells recovered" were tried, as well as mechanical appliances, and finally, since the limb was useless and

in the road, amputation was advised. Recognising the all importance, in spite of the views of the Cambridge School, of the quadriceps in paralysis of the lower limb, the opinion was expressed that were the limb straightened, flexion of the limb could be prevented by any appliance which converted the limb into one piece, and, though formerly using the Thomas caliper knee splint, applied, owing to certain advantages, the splint here shown. These questions I have

SPLINT FOR LOWER LIMB AFFECTIONS.



A B C Wings which are hinged at back D Bolt through heel.
Lateral stems are hollow to lighten the splint.
Knee is hinged to various angles of flexion, or may be fixed.
Splint is open; when closed, wings are connected with straps

dealt with in other chapters, and may mention, in passing, that the contracted knee was straightened without operation, merely by the continuous pressure of adhesive plaster and bandages, for if a muscle contracts it will relax if coaxed to do so, and if the pressure, however slight, be continuous, since as the distinguished Lamarck once wrote—"Organs adapt themselves to conditions of existence." Soon he was enabled to walk about with the caliper splint on, and the extended crab splint was used at night to main-

tain a relaxed quadriceps, and prevent contracture. Six months later, the boy returned walking well with the splint on, but, in spite of the lengthy relaxation,

it was interesting to note that the quadriceps had not recovered its function since the boy was unable to extend the leg from even quarter flexion, nor raise the heel from the table, even though lying over on the side. To be clear, I will briefly summarise his condition:—A straight knee—unrecovered quadriceps —ability to walk and stand by means of a caliper splint, and the prospect, if no caliper, by means of arthrodesis, knee excision, or tendon transplantation.

II.—The Study.

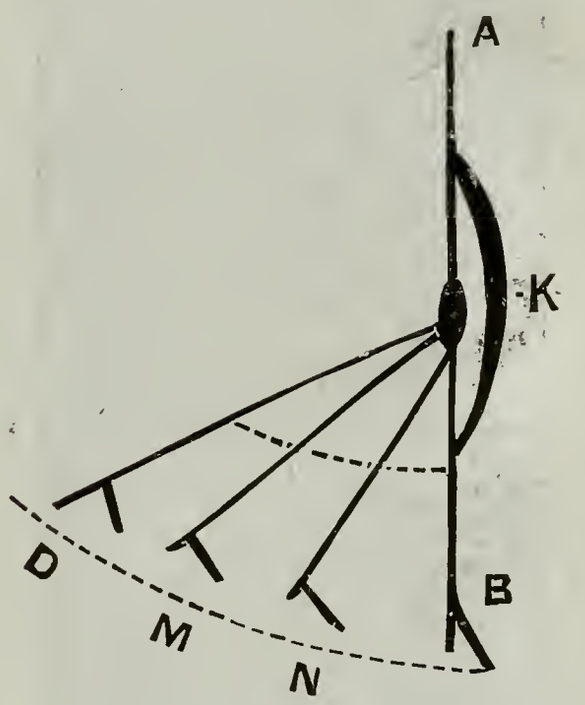
It is necessary, in the first place, to recognise that the inherent possibilities in function of a voluntary muscle must be enormous. Its action is not continuous—it intermits; rest is essential. Thus, a comparison in function is permitted, and so improvement in action is effected. In other words, we recognise as a principle that its acquisition of power of action, as opposed to the heart muscle, is gradual or developmental. Again, when anatomically we speak of a muscle as being flexor or extensor, we really refer to the maximum function of the muscle, and the question must always arise as to the physiological minimum of muscular function, for it is only by the recognition of that minimum that the affected muscle may be ultimately coaxed up to the maximum. In other words, we recognise what I have previously termed the zero position of muscle. It may be stated that a muscle is rested when it is placed in a position where its work is zero, and its origin and insertion are as nearly as possible on a level, since the resumption of function, which should be gradual, is always easiest along a straight line.

The further treatment of this condition, then, may be summed up as the encouragement of voluntary muscular movement within functional limitations. Muscular movement must not be done for the patient; he must do it himself. And, though we may think that the minimum work is slight to coax, *e.g.*, the quadriceps, to extend from say two inches of flexion, we must remember that it really represents the maximum function of the muscle for the time being, and as such may soon exhaust, in the same way as the ordinary individual would soon tire if asked to continue flexion and extension of the forearm to the full extent.

The question is not one merely of relaxing an overstretched muscle, as by splinting or the maintenance of equilibrium; for relaxation means muscle stagnation—no where more than in relation to the quadriceps—and as a doctrine is fallacious, since it is really the placing of a muscle at the zero position; and

splints are useful for the maintainence, when the muscle is not exercised, and their limitations and conveniences as such should be recognised. In the case of the quadriceps, the zero position would be the extended knee, with the patient lying down. Hence, if that muscle be affected, it should be placed in this position by means of a splint. If it be an old contracted case, the contractures must be overcome, and the quadriceps placed at zero before any commencement can be made to see if the muscle has really recovered.

The zero position is represented by the line A—B, where K is the quadriceps. The maximum extension



would be from the flexed position D to B, but why ask it to go through the arc of the circle D—B before we know whether it can go from N to B.

The contracted knee is a neglect of that principle, as is perfectly obvious. With a reflection to N, we should extend to B. From M to B and from D to B, but it is quite fallacious, as is too often done by masseurs, to ask a weakened quadriceps to extend from D to B *ab initio;* in other words, it is incorrect to flex the knee beyond a point at which extension fails.

Still, we have not obtained our ideal, viz., the ability of the patient when lying on the back to raise the heel off the ground with the knee extended; but turn

the patient completely on the opposite side and so alter the leverage, and our patient will be able to swing the limb from the hip in one piece, *i.e.*, with the full knee extension and hence to get back to our ideal, we must gradually alter the tilt of the body, which can be done by means of a pillow, from the lateral to the supine position, and so, finally, the maximum is reached. Then will the patient walk and stand with confidence, otherwise he will need sup-

Fig. C.

port. If at the minimum, something to render the knee rigid to permit of a swing from the hip, and between that and the maximum, some form of support which only allows flexion at the knee, corresponding to the power of extension.

On these principles was the boy's quadriceps exercised, not once, but many times a day, and within one month, *mirabile dictu*, he was enabled to raise his

heel in the air, and maintain it there, thus accomplishing the most difficult function the quadriceps can perform, and also to stand and walk without support on the affected limb, as seen in figure C.

I confess the problem submitted here is not easy of explanation. Paralysis of the quadriceps has been, perhaps, the greatest stumbling block to deal with in infantile paralysis, and is, of course, responsible for the large amount of crutchdom seen in any large city as a sequel of the condition. The result is not an isolated recovery, but has been accomplished in numerous other instances, both recent and old, only this case is taken, because it represents the worst that a paralysed quadriceps could suffer. After fruitless attempts at treatment many years ago, the boy was regarded as incurable, the affected anterior cornual cells presumably destroyed, the muscle as irrecoverable, and so, better than a dangling useless limb, amputation was to be preferred. For nearly ten years those cells, even if they had recovered, were never used, hence there were two factors at work, firstly cell involvement, secondly atrophy from disuse. Relaxation for six months does not cause recovery, yet in one month, a scientific working of the muscle causes a regeneration or re-education of affected cells, or were adjacent healthy cells called on to functionise?

Pertinently, the question arises—were the cells alone affected? Was the muscle also or alone the seat of the disease? That the muscles, apart from atrophy, are the seat of change is undeniable. The purpose of this chapter, however, is not to discuss causation, but to state certain suggestive facts, for otherwise questions arise, such as affection and recovery of muscles largely muscular in character, or partly muscular and largely tendinous, and developmental questions are raised. But this may be mentioned that, where the educative muscular sense is deficient, as in early life, then, from our arguments, would be expected the difficulty in recovery to arise, and truly enough this is so; and; again, in the muscles of the feet, where origin and insertion are practically at a right angle, it it extremely difficult to initiate function.

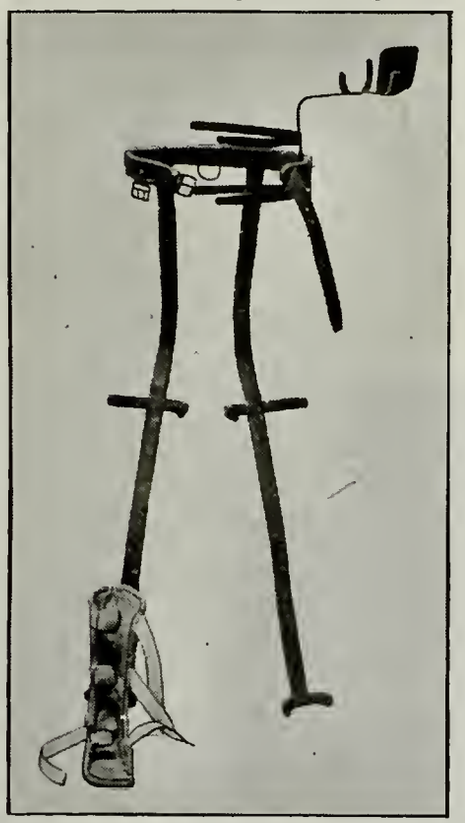
PARALYSIS OF THE NECK, BACK, AND ABDOMEN.

Neck Muscles.—Paralysis of the neck muscles, with inability to hold the head erect, is not often met with, and, taking a series of 100 cases, I only met with it twice—in both associated with paralysis of all four limbs, with inability to sit up. These cases do well, owing, I apprehend, to the little tendinous character of the cervical muscles, and to the good natural rest recumbency affords—maintenance of which alone, apart from the encouragement of voluntary muscular action, usually suffices for recovery.

A case of Paralysis of Muscles of Back, Neck and Four Limbs.
Child unable to sit up without support.
Back of head resting on the spine.

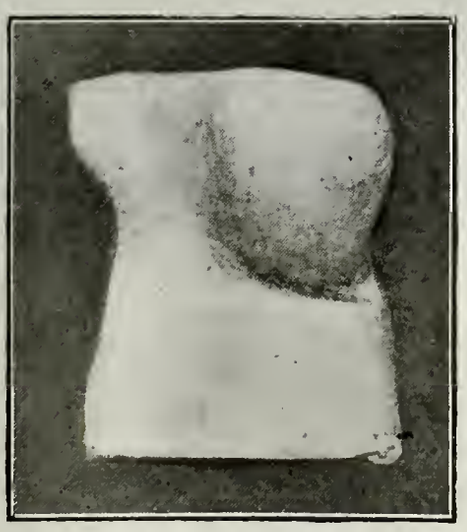
Back Muscles.—Paralysis of these, with inability to maintain the erect position when sitting in bed, is more frequently met with than the former, and usually accompanies affection of all four limbs, and frequently paralysis of the two lower ones. Complete rest of lower limbs in a double Thomas' splint, and if neck affection be present, with head extension also, is advisable. Good recovery is to be looked for owing to reasons similar to the above. Education of the

back muscles is, however, necessary, and the alteration from recumbency to the erect posture should be gradual by means of pillows. Probably the best and simplest exercise for strengthening the back muscles



How a Double Thomas Splint may be modified to treat Paralysis of the Back, Left Upper, and Right Lower Extremity.

is to attach a soft rope to the middle of end of bed or cot, with knots at short and even distances, along which the patient is encouraged to pull.



Plaster Cast of Back from an old case of Paralysis
The Right Thorax overlaps the Ilium.

Abdominal Muscles.—As is the case with the neck muscles, paralysis of the abdominal muscles is not frequently met with. It is usually not seen unassociated with paralysis of the lower limbs. Unfortunately, it is frequently overlooked in the early stage, and the first evidence of its presence may be, perhaps, ballooning of one side of the abdomen. This absence of early recognition may prove disastrous owing to pelvic tilting, the result of contraction of the abdominal muscles of the opposite side, with apparent lengthening of the lower limb on the affected side, and the usual later production of lateral curvature.

An old case of Pelvic Tilting, with apparent, but not real, Shortening of the Left Side, and marked Spinal Curvature.

This pelvic tilting, if unwatched, occurs rapidly, and even in infants may resist all forcible measures for its correction, and yet its prevention is of the simplest. In a case with one or both quadriceps muscles affected, since one is never able to be certain

of the muscles about the abdomen and hip, it is preferable to use either the frame here shown, by which abduction or adduction is regulated, with a firm abdominal binder or adhesive plaster; or a double Thomas splint, having a wide piece of webbing for the abdomen affixed, extending the leg pieces round the feet like a crab splint, the stem being extended at the knee for the quadriceps, but flexed at the hip to ease the psoas—straightening the hip and flexing the knee as recovery takes place.

A Double Hip Splint modified to treat Muscles of Neck, Back, and Left Lower Extremity.

In the abduction or adduction splint the stems are made of ⅝ malleable iron, and the wings also made of malleable iron, ½ inch by 1-16, are attached at the upper third of the thigh, and at the termination of the stem opposite the lower third of the leg. At the top the two stems are connected by a piece hinged at the centre, made of ½ inch by ⅛ inch malleable iron. The upper connection lies beneath the buttock. If necessary, the arc feet splints may be fitted to the lower wing. The stems are connected below by, as

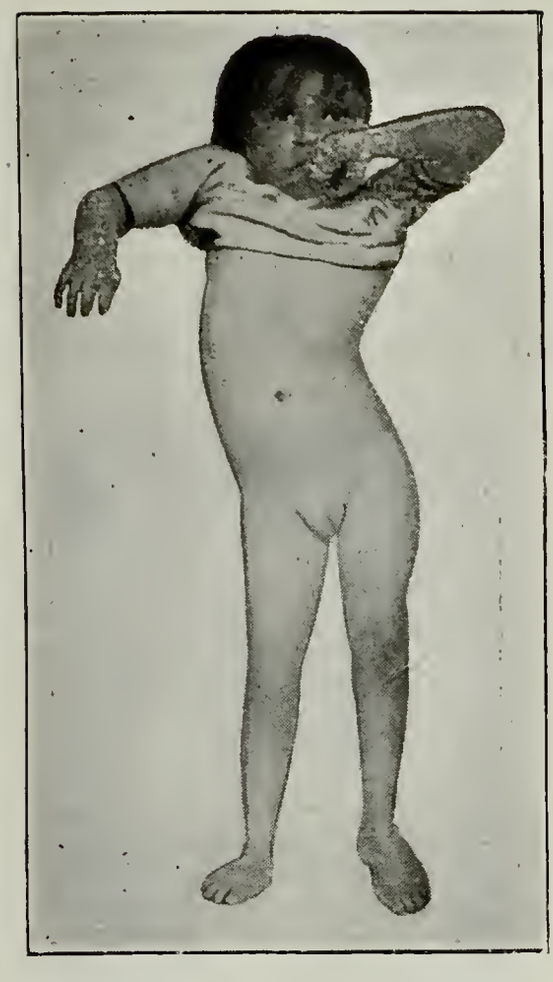
in illustration, on one side a solid piece made of 5/8 inch malleable iron, and on the other a piece slotted, into which the solid piece fits and works, in this way accommodating itself to either adduction or abduction of the limb. The parts are held in position by means of a thumb-screw. Both stems and wings are covered over with basil leather, or, preferably, chamois. The patient may be either bandaged to the stems or held in position by means of straps and buckles attached at the wings.

The Writer's Abduction or Adduction Splint.

In this way the tendency to external rotation and abduction, with pelvic tilting—not controlled by the ordinary leg splints—is obviated.

In reference to this question of pelvic tilting, two cases are here shown, which illustrate in a remarkable way the only too-evident truth of the above assertions.

Case A.—This represents a girl, æt. 3 years, affected with paralysis of both lower limbs and the right abdominal wall. She was untreated by any form of splint, and the present condition was apparent eight weeks after the onset. There is marked pelvic tilting and apparent lengthening on the affected side, with apparent shortening of the non-affected one. There is spinal curvature present—the tilting not responding to even forcible traction.



CASE A.—Showing Commencement of Spinal Curvature and apparent Shortening on Left Side.

CASE A.—Showing more markedly the apparent Lengthening on the Right Side, with some External Rotation present.

Case B.—This represents a case of paralysis two years after the onset, and the result is in spite of the fact that the mother absented herself from the clinic at one period for fifteen months. As the writer considers it the worst case he has seen recover, he may be pardoned for entering into some details. The patient was first seen three days after the onset in an exhausted state, and little hope of the child living was held out to the mother. If the child were sat up sup-

Case B.—Recovery of Lower Limbs without Pelvic Tilting or apparent Shortening.

ported, the head fell back on to the spine, as though supported by nothing more than the skin. The child was unable to sit up alone. Complete paralysis of both upper and lower extremities was noticed, and the right anterior abdominal wall also—a truly terrible affection—both arms, both legs, back, neck, together with the abdominal muscles. Immediately on being seen, the child was immobilised in a double Thomas'

splint, to which the extension for resting the head and neck was added. Separate crab splints were applied to the feet, and the stems of the splint were flexed at the pelvis, and straightened at the knee, as recommended above. In addition, two of the upper limb splints previously described were affixed to the splint.

For four weeks the child was kept immobilised in the splints, the limbs only being raised daily for sponging purposes, and then the muscles were gradually worked as recommended. The neck muscles were the first to recover.

She was immobilised in the complete splint altogether for five months, and later we used the extended crabs and the arm splints only. In spite of the fact that the parent was so negligent over the child's treatment, she is now able to stand and walk without support, has no abdominal weakness, and the back and neck have recovered perfectly. It is certainly in marked contrast with the previous case, and this in spite of the fact that she had, in addition, affection of the back, neck, and both upper extremities. She has recovered without any pelvic tilting, or any semblance of curvature. In treating and observing this case, I was assisted by Dr. Nankivell, of Nhill, and in spite of the fact that this meant visiting the patient at a long distance every night for many months, it well repaid the trouble spent, since its results justified the soundness of our treatment.

TREATMENT OF CONTRACTURES.

"In animals, wrote Hunter, there is more variety of motion, but in plants more real power. A small vine can raise a column of fluid five times higher than a horse can; for the same energy which, in the animal world, is weakened by being directed to many objects, is, in the vegetable world, strengthened by being concentrated on a few." Concentration of force may be regarded as a first principle in treatment, and in no cases is it more applicable than in the treatment of contractures in the young. In other words, given a pressure, however slight, but continuous and concen-

Old case of Contractures, with a 14 years' history—Knock Knees, and a condition of Valgus of the Left Foot.

trated, and contractures, even of the extreme and apparently hopeless type, will be found to yield without the aid of what should always be the last, and not the first, resort—the knife. And, provided that principle be borne in mind, it matters little by what instrument it is carried into effect. If a muscle contracts, it will relax if coaxed, but not forced, to do so, and if the pressure, however slight, be continuous, owing to the adaptability of organs to conditions of existence.

It must be perfectly obvious that, if the foregoing treatment be systematically carried out, contractures will never occur, and such a condition—e.g., acquired Talipes Equinus—be unknown. Yet frequently it is to overcome these that we are consulted.

Contractures are most frequently met with in connection with:—

I. Lower Extremity.
II. Pelvis.
III. Upper Extremity.

Lower Extremity.

Ankle Joint.—Conditions of acquired Talipes Valgus (eversion, weakened Tibials, overacting Peronei) (A) and Varus (B) (inversion, over acting Tibials) in children respond particularly well to manipulation, provided it be persistent, and I have seen an extreme varus in a girl of 12 years overcome in this way, and naturally such conservatism tends to strengthen than weaken the joint.

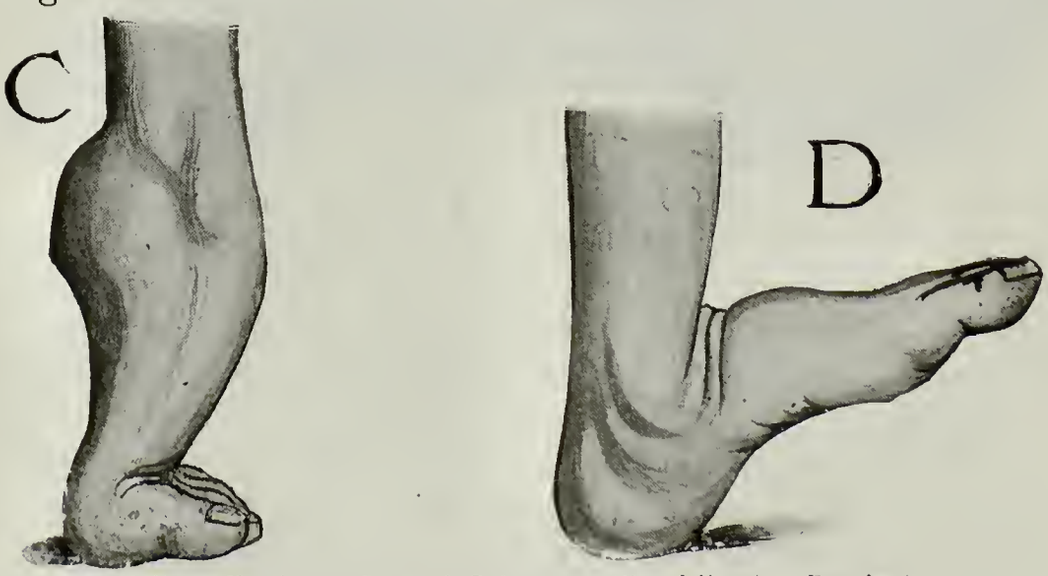
Talipes Valgus (A), and Varus (B), following Paralysis.
(From the writer's Preparations in the University of Melbourne.)

The mother may be easily taught how to manipulate, and a splint should be provided, so as to take advantage of the results of manipulation.

Talipes Equinus (C) the result of overaction of flexors of the leg from paralysis of the extensors, when of recent date, responds to manipulation and the use of the foot shoe previously shown; but, if old, the tendo-Achilles forms such an unyielding band to

Old-standing case of Talipes Equinus—Knee Contracture and Paralysed Quadriceps.

manipulation that, on the score of time alone, lengthering or division of the tendon is advisable.



Talipes Equinus (C), and Calcaneus (D), following Paralysis.
(From the writer's Preparation in the University of Melbourne.)

Talipes Calcaneus (D), the result of overaction of the extensors and paralysis of the flexors, is rarely to be met with, although, in cases of flail ankle joint, the foot may readily be made to assume that position —the result of paralysis of both flexors and extensors.

The Bones from an old case of Talipes Equinus.
(From the writer's Preparation in the University of Melbourne.)

Knee and Hip Joints.

Next to the ankle joint, contractures at the knee is the one most frequently met with, and often in conjunction with a similar condition at the hip. For these forced straightening under chloroform—division of hamstrings and ilio-tibial bands and other muscles are the methods usually employed—no imitation of

nature, but an endeavour to overcome in a few minutes what has often taken years to produce.

In illustration of the methods of continuous pressure, the cases of two cousins may be quoted.

To illustrate the Case (A) mentioned in the text.

Case A.—A boy, æt. 10. with a rigid, unyielding, contracted knee (angle of flexion about 65 deg.) of eight and a half years' standing, with backward displacement of head of tibia. Amputation had been advised. A Thomas' knee bed-splint for convenience was applied to the limb, and a bandage from front to back of the ring over opposite shoulder. Adhesive plaster was applied alongside of knee, and wound round the lower part of the splint, care being taken to tighten it daily, no weights being used. Little pressure pads of wool were applied, with bandages above and below the knee. For some weeks there seemed little give; then the angle lessened, the adhesions gradually yielded, and in two months we had the satisfaction of turning the bed into a caliper splint on a comparatively straight limb. The patient now walks without any trouble. He has his limb intact

without the prospect, as is the case after excisions, of a very much shortened limb. Such a condition could also be overcome by the use of an ordinary back splint, with movable foot piece—applying pads above and below the knee, and fixing the limb with an ordinary bandage.

Case A.—Contracture Reduced, and Bed Splint converted into a Caliper.

Case B.—The next case is that of a boy, æt. 10, who had never walked, being attacked with infantile paralysis eight and a half years previously. It was the most extreme case possible to meet. The condition was as follows:—There was marked atrophy of the lower back muscles. Paralysis of both lower limbs, as shown by foot-drop, and no quadriceps extensor

power. The angle of flexion at the hip, owing to the contraction of everything about the joint, was 90 deg.; in addition, there was extreme adduction. The knees were also contracted, the angle being that of preceding case. On stiffening both knees, we found he could swing from the hips, and regarded him as

To illustrate Case (B) mentioned in the text.

having a possible chance of walking. The contractures at the knee were quickly overcome, as in the preceding case, without tendon division. For the hip, the following simple method was used:—Thomas' bed-splints were applied to each limb, with the object of converting them into one rigid piece, and so improving leverage. A bandage went from the lower end of each splint to end of bed, and from the bandage round each shoulder to top of bed. No further fixation was used, the patient being kept on his back. No

division of tendons, no weights, and yet to that small amount of expended continuous energy the rigidity gradually yielded, and in six months we had the satisfaction of exhibiting the patient, walking with crutches, practically straight, the bed-splints having been converted into the calipers. It was a good example of how a small pressure will alter the direction of abnormal tendency.

Front View of Case (B), showing Contractures at Hip, Knee, and Ankle Joints, with Pelvic Tilting.

A case from South Africa, similar to B, commencing to walk.

Result after Six Months of a case of Acute Contractures of both Knees, with Double Foot Drop.
Seven months' history when first seen.

The following case, from Malmsbury, is of no small interest, owing to the long history—viz., 13½ years. In spite of years of massage and electricity, he lapsed into this apparently hopeless and pitiable condition, and seemed to be the victim of every possible evil of this disease—viz., marked spinal curvature, knee contractures, double talipes, pelvic tilting, and apparent

Front View of case mentioned in text, with apparent, but not real, Dislocation of the Left Hip.

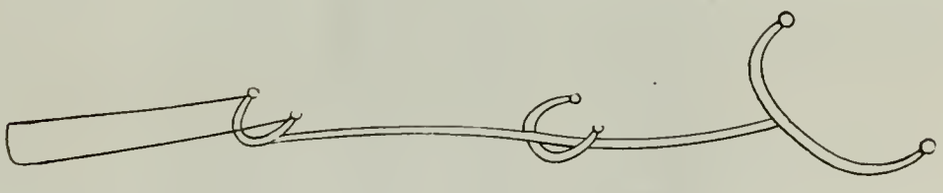
lengthening and shortening of the limbs. He had never walked, but was either carried or crawled about on his hands and knees. He is shown three months

Back View of case mentioned in the *text*.

later, when he commenced to move about, with the aid of crutches, and he can now stand alone.

PELVIS.

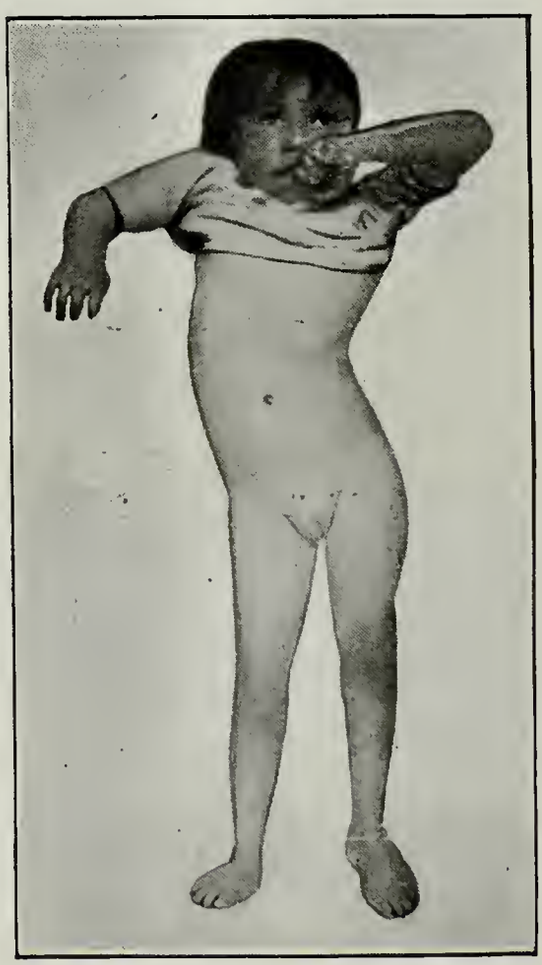
Pelvic tilting, associated with a weakened unilateral abdominal wall, once allowed to occur, rarely responds to treatment. I have tried fixation of one side with traction on the other without improvement, even in babies.



A Tubular Steel Piece attached to the Leg Wing of an ordinary Hip Splint to secure Extension of the Thigh and Leg.

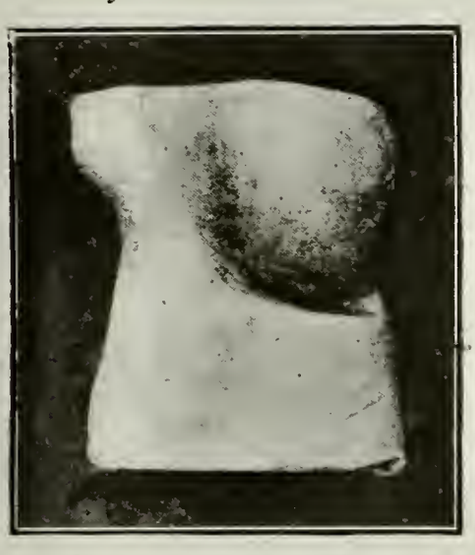
The disastrous consequences only serve to emphasise what has been already pointed out, viz., the importance of obviating it at an early stage, even before

we recognise a paralysed abdominal wall. This condition is usually aggravated by the building up of the boots on the apparently lengthened side. As a mat-



To illustrate Pelvic Contracture in a recent case, with Paralysis of the Right Abdominal Wall.

ter of fact, in old cases, this correction is usually the most important we are called upon to make, though, at a late stage, the treatment really resolves itself into that of curvature of the spine and spinal stretching. Massage, gymnastics, and the use of a spinal jacket moulded into the shape of the stretched spine may all be necessary.



Plaster Cast of an extreme case of Spinal Curvature, associated with Pelvic Tilting.

Upper Extremity.

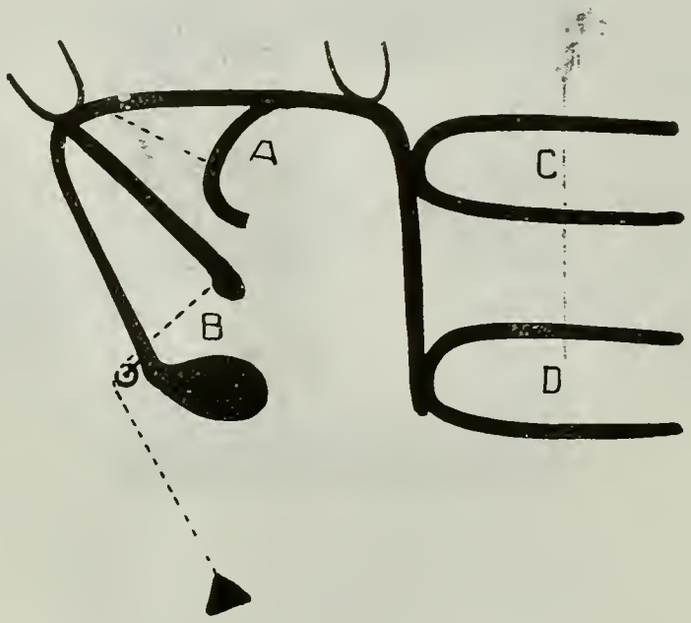
Here contractures are less common than in the lower limb, and usually more responsive to treatment. In this disease it is rare to meet with a case of wrist drop in which education of paralysed extensors is interfered with by contracted flexor tendons. The common ones are over-pronation of the forearm, contracted elbow due to the biceps and brachielis anticus, and adduction of the arm due to pectoralis major and minor. The two latter are readily overcome by gentle manipulation, applied, not once, but several times a day, and in the intervals applied traction by means of a bandage and plaster adherent to a modified upper extremity splint.

In adduction of both shoulders a simple splint extending across both scapulæ, to which the arms are bandaged, will be sufficient.

Over-Pronation of Forearm.

This variety—the result of paralysed supinators when of old standing—is probably the most difficult contracture of all to overcome. When recent, gradual

manipulation and the use of the upper limb splint, the tilt of the hand piece of which may be gradually altered, suffices. When not of recent date, and owing largely to the additional contracture of the ligaments about the wrist joint, it may be necessary to use forced manipulation under chloroform and plaster of Paris, or even division of tightened bands may be essential.



The writer's modified Upper Limb Splint —

At A, traction is applied for an adducted arm.

At B, traction is applied for contracted elbow, either by plaster or weight and pulley.

C and D, chest wings.

The illustration shows the case of a boy with a paralysed arm of 15 years' standing, in whom, in spite of the long history, recovery of the deltoid and biceps speedily resulted, which, however, will be useless till the extreme over-pronation of the forearm be overcome.

Conclusion.

In children afflicted with this disease, conservation rather than destruction should be our aim—the preservation of structures round a joint rather than their division. The citement of the cases quoted shows that, before dividing adduction tendons, or hamstrings, or in the upper limb pectorals or biceps or

other structures, a recourse should be had to a concentrated energy, no matter how slight, but continuous.

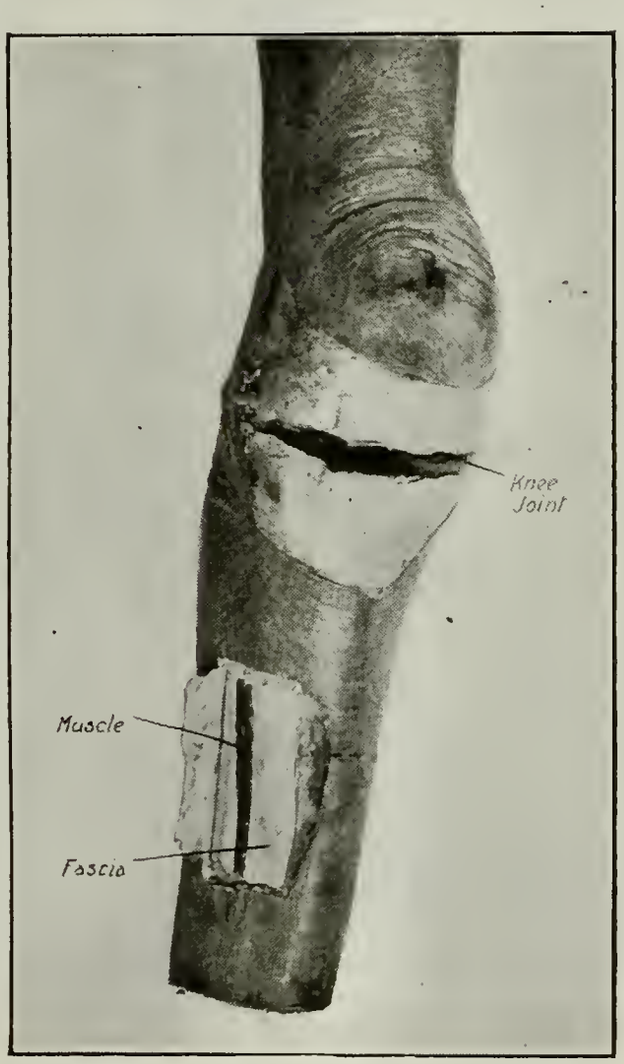
SURGICAL PROCEDURES.

An enormous impetus to the treatment of the disease has undoubtedly been received from operative interference. Yet it will be admitted—and in this Dr. Kermisson and the French school are not alone—that its utility is limited, and that the results, as seen subsequently, have not realised the hopes anticipated. We must remember, of course, that to the orthopedic clinics of Europe cases are not sent in the early stages, and, as we have already stated, it is only by thorough treatment at this stage that operative treatment subsequently will be obviated. Nor are cases seen early always by the practitioner; and frequently, when they are—since the results appear slowly, and careful attention is necessary—these patients find their way into the hands of those charlatans and quacks who exist in the Commonwealth, as they once did in ancient times in Athens. Hence, after every epidemic, cases will be met with for which some operative interference may be necessary.

Division or Removal of Deep Fascia Over Muscles.

Although it is common enough to see that, as we formerly thought, most hopeless of all muscles, the quadriceps extensor of the knee, after being condemned both on electrical and utilitarian grounds as hopeless, brought back into action, it may be stated that no muscle should be condemned, provided there be no mechanical interference with its working. It is usual to speak of the contraction of strong, unaffected, antagonistic muscles as the great bar to recovery, and that certainly is an important factor; yet the deep fascia over muscle as a factor seems never to have been considered. An affected or paralysed muscle means a muscle whose work has been interfered with, and in the animal economy diminution of work means atrophy of tissue. The deep fascia which,

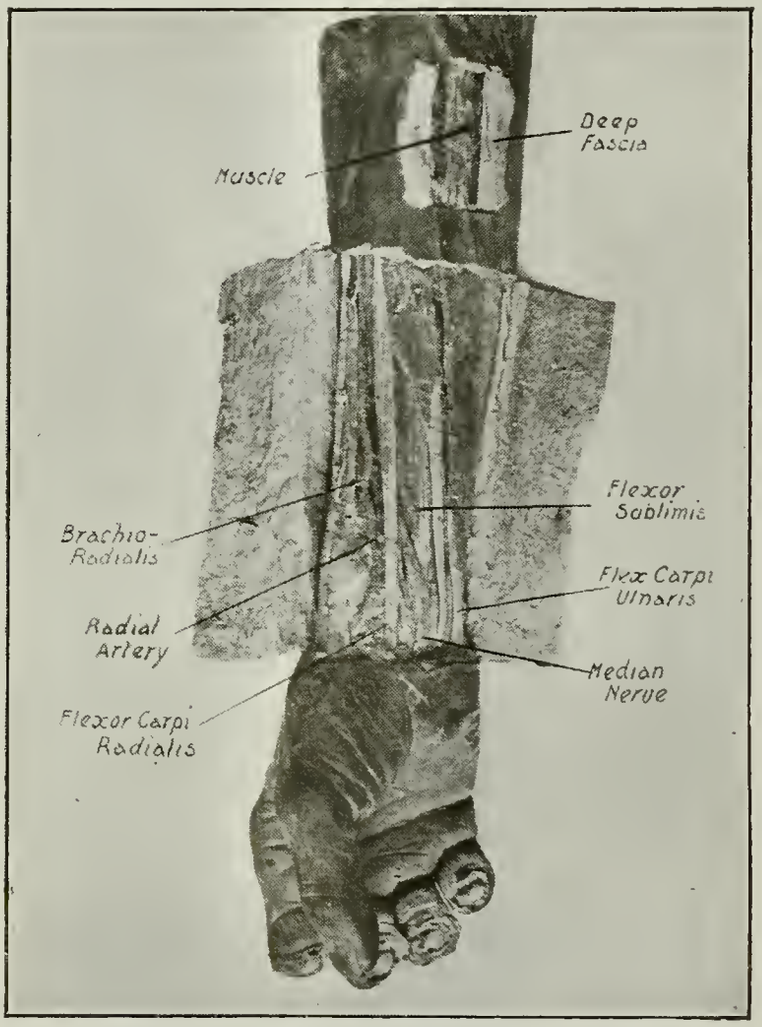
e.g., in the forearm and over the extensors of the leg, form a little yielding, firm band, accommodates itself obviously to the muscle condition present. When later a call is made on the muscle for increased work, it is found to be mechanically bound down, and thus a mechanical barrier exists, as great a hindrance to recovery as a contracted tendon. Recently five instances of paralysis affecting the extensors of the foot



Dissection to show Relation of Fascia and Muscle in the Upper Leg.
(From the writer's Dissection in the University of Melbourne.)

without movement of the toes for two years were seen, in which an incision over the muscle origin revealed in all abundance of muscular tissue; and in two cases of division and three of removal of the deep fascia, room was given to the muscles to expand, the fascia being simply contracted down on an affected muscle. The result was in all recovery in a few weeks of extensor power. In one case soamin was

injected into the muscle at varying times. In another of eight months' standing with foot drop, on incision of the fascia, an anæmic mass was seen, which, on its removal, swelled up for about one-third of an inch, presenting itself as apparently useful muscle, as was shown subsequently by action and by the microscope.



Dissection of the Front of the Forearm to shew deep Fascia and Relations of Structures at the Wrist.
(From the writer's Preparation in the Department of Applied Anatomy.)

In this connection Dr. Perry, of Melbourne, records an interesting observation on a boy, æt. 6 years, suffering from infantile paralysis of the left arm, with a four years' history, during which period he had had continuous massage, but no rest, nor had voluntary movement ever been encouraged. On examination the whole upper extremity was markedly attenuated. When standing he was unable to raise the limb from the shoulder either in abduction or adduction, but

could slightly when lying down—and similarly with flexion and extension of the forearm. Beyond a slight attempt at flexion of three fingers, there was no other movement of the muscles of the front or back of the hand or wrist, and the forearm was described as apparently little else than skin and bone. Yet a vertical incision three inches long from elbow down the front and back of the forearm, with division and removal of the deep fascia, showed the presence of every forearm muscle, both front and back, attenuated and anæmic, but still present, and the appearance, after five minutes of relieved tension, showed absence of pallor and macroscopically healthy muscle. The whole appearance was a surprise and a revelation. Yet externally there was no mechanical interference to the action of the muscles—no contracted antagonists. It may be mentioned that there was evidences of adhesions of fascia to muscle, and unhealthy thickening of the former in places suggestive of old inflammatory trouble previously.

The boy is now recognised to have muscles capable of hypertrophy, capable of work, and encouragement to action will be carried out on lines previously indicated. The flexion of the two terminal phalanges and extension of the proxinal one will be treated by extending the fingers and commencing flexion from the extended position.

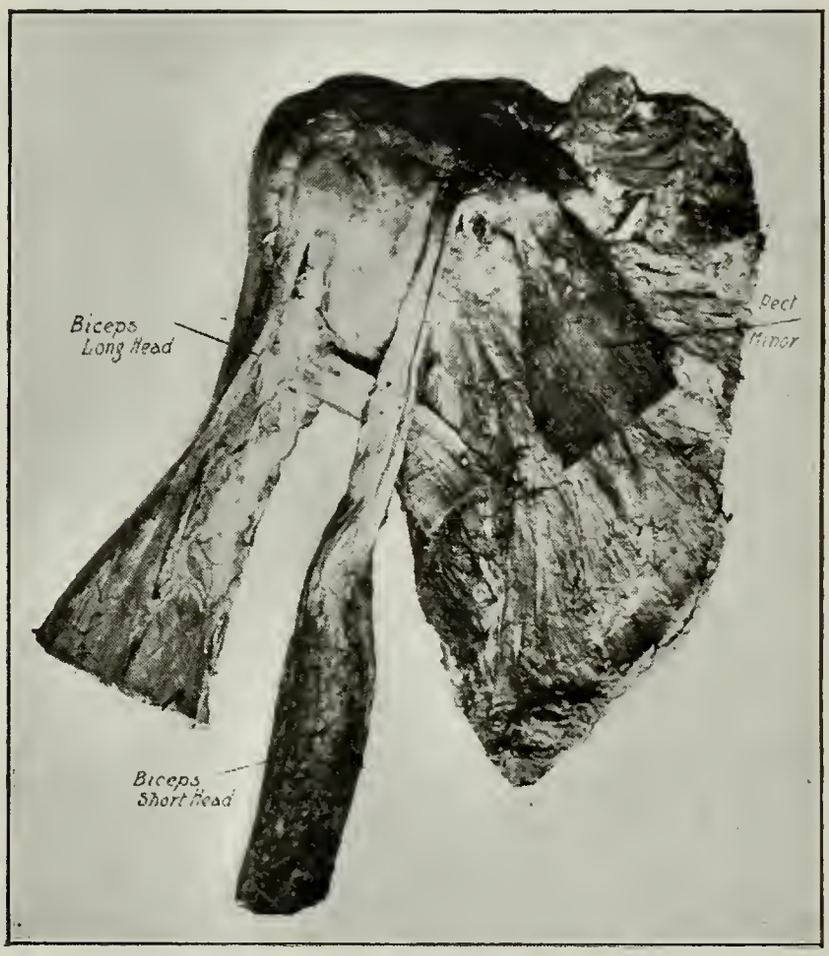
Hence, before operating on, say, the extensor group of muscles in the leg by shortening or tendon transplantation, such a procedure, since it is both easy to perform and harmless in its results, is to be recommended.

Muscle Relaxation and Tendon Shortening.

In cases of foot and wrist drop, owing to paralysis of the extensor muscles, a favourite doctrine of the late Owen Thomas has been utilised, viz., that an overstretched muscle will not recover, and may, if relaxed. Hence, in cases of partial paralysis, these muscles may be placed in a state of relaxation by means of splints. Should no recovery take place, as, in my own experience it rarely does, the procedures

of shortening by silk or catgut the elongated, and lengthening the contracted tendon may be tried in these partial conditions.

In cases of foot drop associated with laxity of the ankle joint, shortening of the extensors is a favoured procedure at the German clinics, on the failure of which arthrodesis is usually proceeded with.

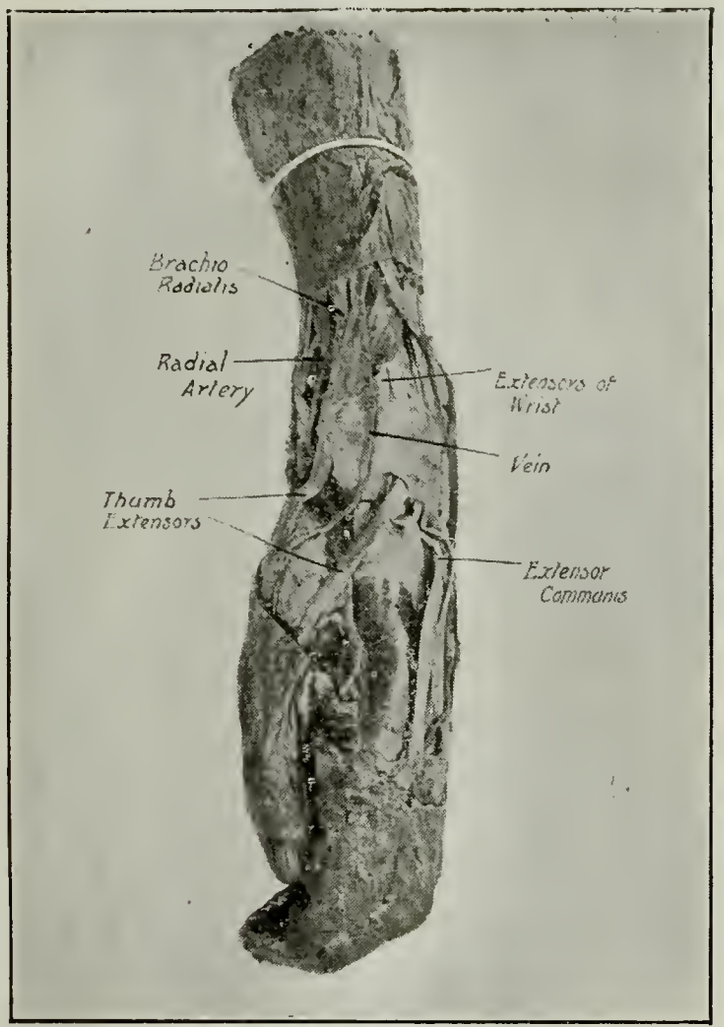


Some Anatomical Relations about the Shoulder Joint.
(From the writer's Preparation in the University of Melbourne.)

Tendon Transplantation and Tenodesis.

In cases of partial paralysis, where shortening is inapplicable, as, for example, the deltoid, and in cases of old standing with loss of muscular function, it may be possible to restore function by transplanting an adjacent tendon or tendons; and since in this disease it is common to find healthy alongside paralysed muscles, the procedure may be of considerable advantage. As in the case of recovery of a paralysed

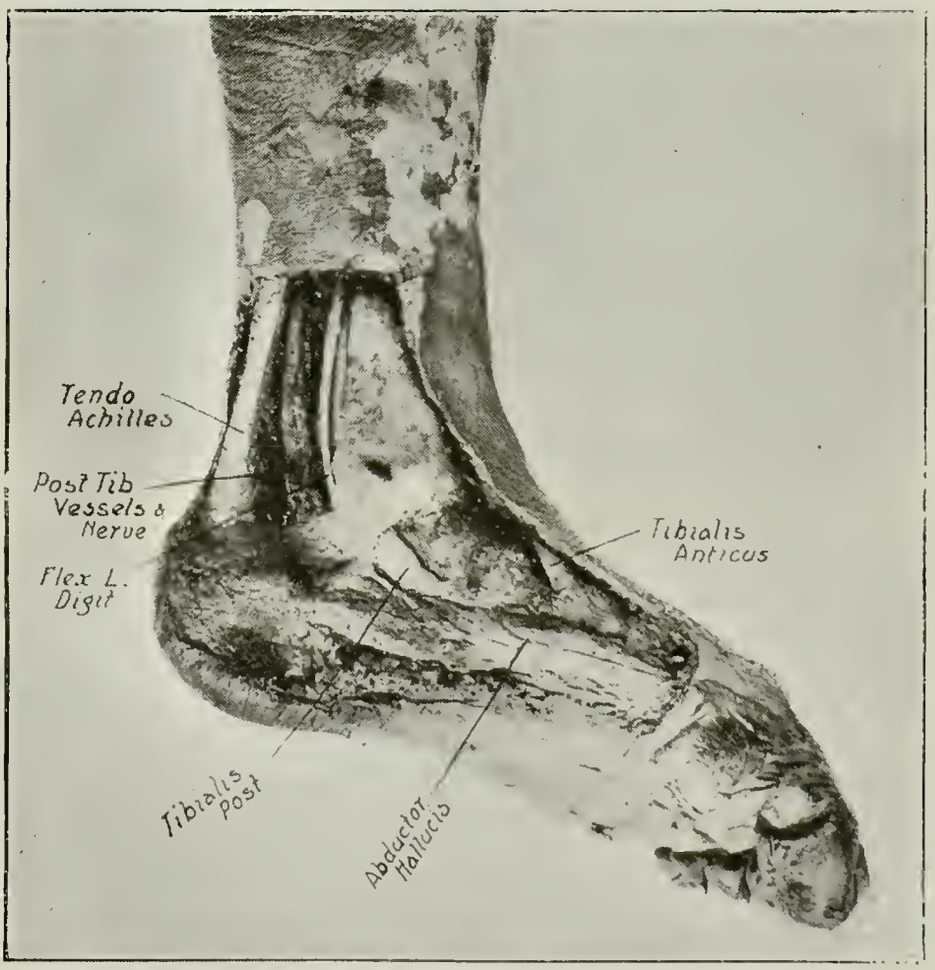
muscle, so with a reinforced one, muscular working from zero, must be insisted on. Inattention to this point is undoubtedly the cause of much non-success here, as well as after operations on the brachial plexus for birth palsies.



Dissection to show the Relations on the Radial Side and Back of the Wrist.

(From the writer's Preparation in the University of Melbourne.)

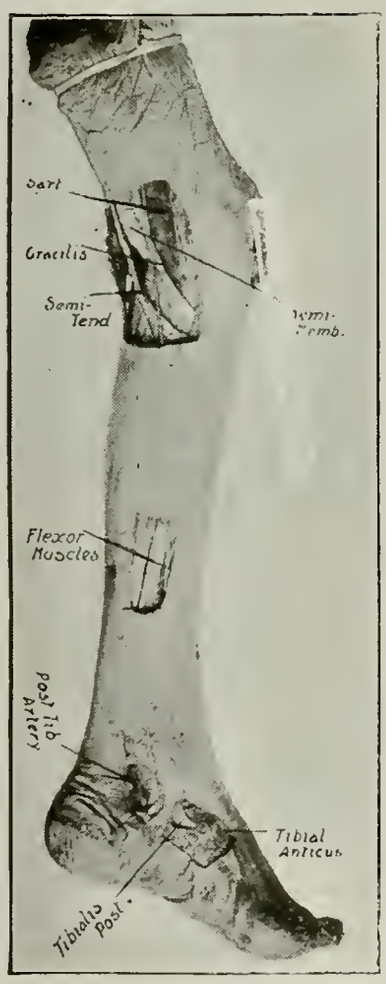
Perhaps the commonest sites for tendon transplantation, and certainly in my experience the most effectual are at the ankle joint, reinforcing the peronei for inverted foot or the tibials in cases of eversion; at the knee-joint, where we may attach the biceps and sartorius to the periosteum of the patella; and the shoulder, where we may reinforce the deltoid from the trapezius and the pectoralis major; and less frequently the elbow joint reinforcing the biceps from the triceps.



Dissection to show the Relations of Tendons on the Inner and Outer Side of the Ankle.

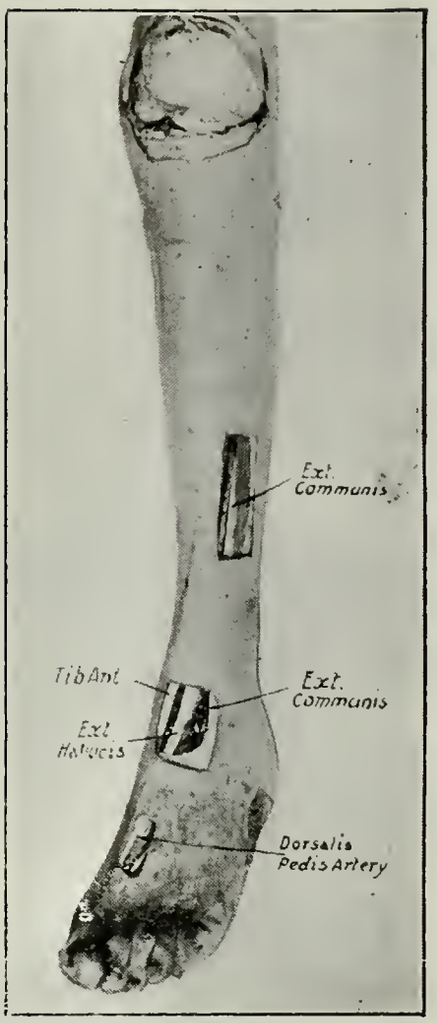
(From the writer's Preparation in the University of Melbourne.)

In tendon transplantation for the extensor of the knee, undoubtedly the ideal muscle is the sartorius. As a matter of fact, in the Australian marsupials, and especially in the wombat, the sartorius is an extensor muscle, and, furthermore, its origin particularly identifies it for the performance of that function.



Dissection to show the Relations of Tendons on Inner Aspect of Knee, Leg, and Ankle.

(From the writer's Preparation in the University of Melbourne.)



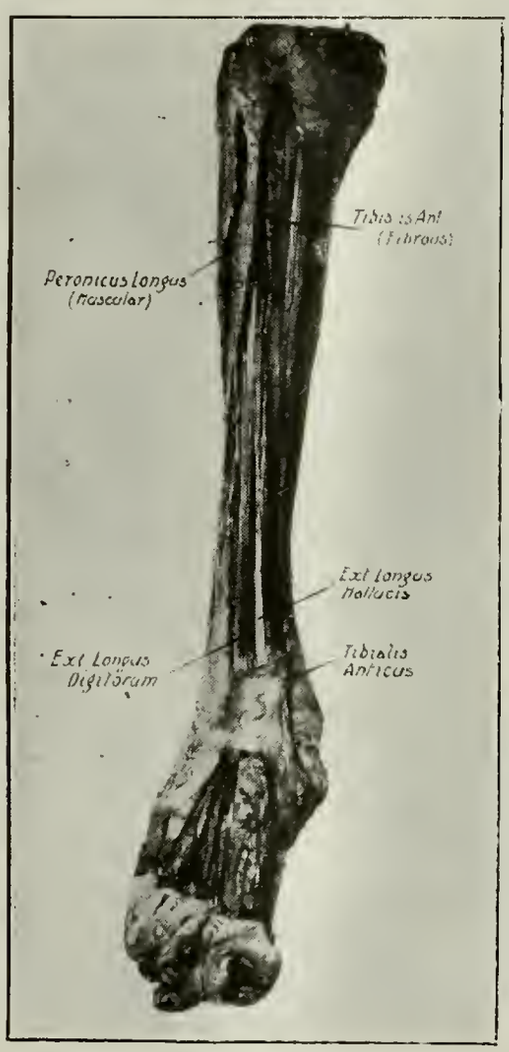
Dissection to show Tendons on Front of the Leg and Ankle.
(From the writer's Preparation in the University of Melbourne.)

When we have a muscle regarded as hopeless, and I refer here to the deltoid in old cases, and an adjacent weak but acting pectoralis major, it is important to strengthen the action of the pectoralis major by voluntary movement and rest before transplanting it on to the deltoid.

At the Liverpool clinic it is regarded as preferable to make the union between the two tendons as near the insertion of the receiving tendon as possible, so as to avoid any possible stretching there. Preference is also given, not to tendon, but to periosteal attachment (tenodesis), though this procedure is more applicable at the knee than elsewhere.

It is scarcely necessary to state that, should deformities be present, they should be corrected before the required transplantation is effected, as, for example, a contracted knee, which should be placed in the posi-

tion of extension, and so rested for at least a fortnight before transplanting. If we transplant first, and subsequently correct the deformity, we have a long, loose donor, whose slack will have to be taken in before we can secure action on the limb, and again in reinforcing, say, the extensors of the forearm from the flexors, it is important to be sure that no interference of the flexion power of the forearm is occasioned.

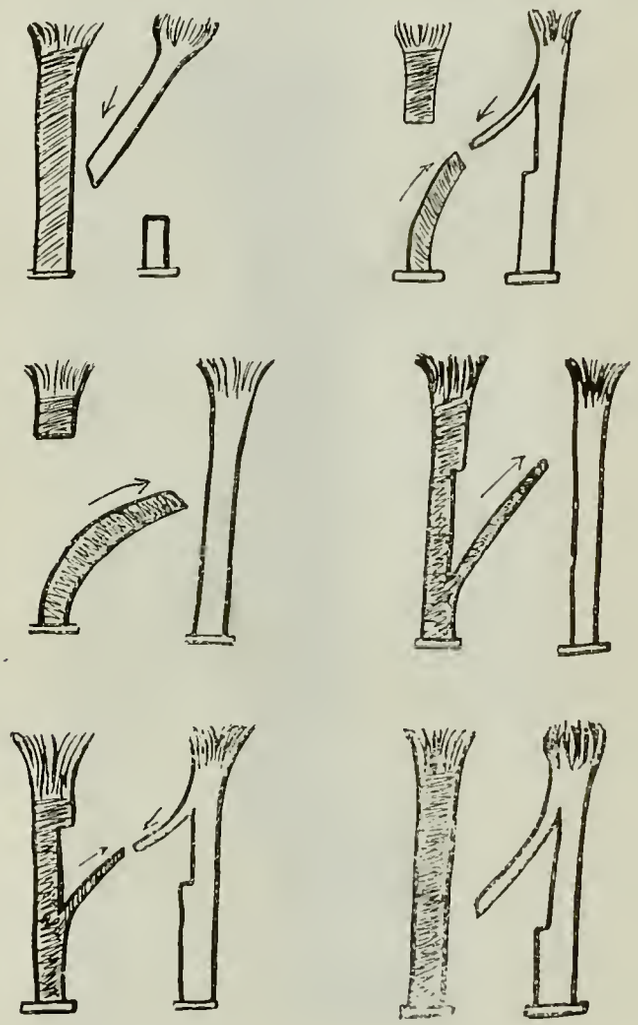


Dissection of Tendons on Front and Outer Aspect of Leg.
(From the writer's Preparation in the University of Melbourne.)

Subsequent immobilisation for at least four weeks is advised, not in plaster of Paris, but in a splint specially made for each particular condition; then later the encouragement of voluntary movement within functional limitations, as previously recommended, is carried out.

In operating, it is, as a rule, best to use a free longitudinal incision, not directly over, but at one

side, to obviate the formation of adhesions. In some cases, as portion of the tendo Achilles to the peroneus longus or to the tibialis posticus, it may be possible to complete the procedure through one incision, but in the dorsum of the foot, where the giver is at a distance from the receiver, it may be necessary to make two incisions, bringing the donor subcutaneously across to the affected tendon. Of course, it is neces-



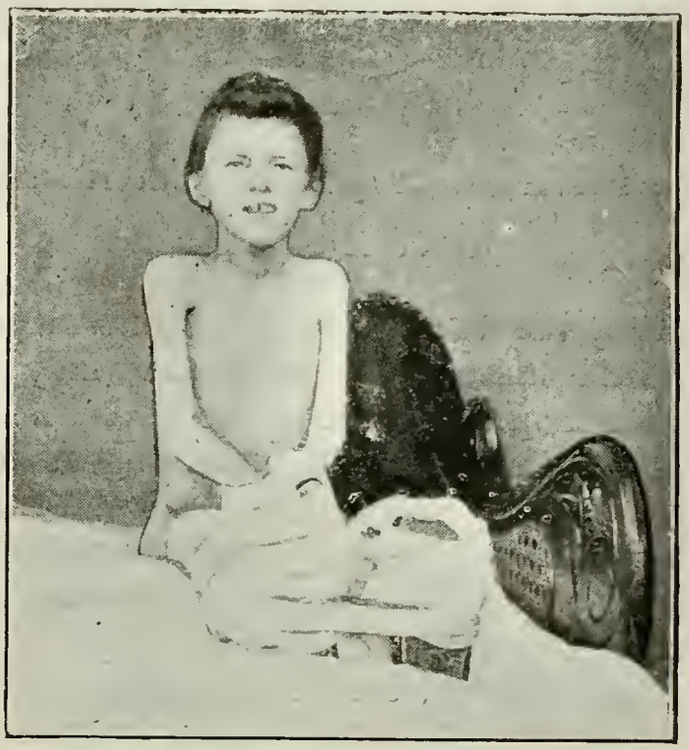
sary to see that no twist occurs in the donating tendon. In the forearm or leg, where we are strengthening flexors by extensors, or extensors by flexors, it is necessary to tunnel through the interosseous membrane. In this procedure it is requisite to always freshen the surfaces to be united, and to see that there be no laxity of tendon between the attachment of the sound tendon, and the insertion of the reinforced end. As we before stated, Jones obviates this by attaching, when possible, the donating tendon, not into tendon, but into periosteum in the vicinity.

The preceding figures were supplied to me at the Heidelberg clinic, and illustrate, without the necessity of description, some of the various possibilities in tendon transplantation. The non-paralysed muscles and tendons are left unshaded, and the affected ones shaded.

Operative Fixation of Joints (Arthrodesis) and Joint Excision.

Considering the varied means at our disposal, it is extremely rare that either procedures may be necessary. And it is questionable if the latter, with its further increased shortening, encroaching as it does on the epiphycial lines, should ever be performed. The former procedure of fixing a joint, namely, arthrodesis, may be merely scraping the opposed cartilaginous surfaces, or removing the cartilages of the opposed surfaces in toto, care being taken not to injure the epiphysial lines. The indication for the operation is for a flail joint, as, for example, a knee in which both the flexors and extensors are hopelessly paralysed. It has been performed in all the larger joints, including even the hip joint, and obviously, on account of the difficulty of obtaining bony union, the older the patient operated on the better. After all, it is necessary to remember that when we arthrodese a joint we really condemn it for life, and even should muscles ever recover they never will have a chance for action. Hence, all possible means of recovery should be exhausted first, and since opening a joint is a serious procedure, many parents prefer to use a splint and boots in the lower limb; and again it is worth remembering that many cases of excisions of the knee-joint in the young frequently return with contracture, and in some cases backward dislocation, necessitating a splint, which the operation was performed to obviate. The ankle joint, which seemed most promising, has turned out most unsatisfactory—a fact not to be wondered at, when we consider that we have body weight constantly acting as a force. Arthrodesis is, to my mind, especially applicable in cases of flail shoulder, where we

have a useful hand and good biceps, and in the absence of the latter, fixation of forearm to a right angle may be performed. By this operation of fixing the



A case suitable for Arthrodosis of the Shoulder, in which a useful Forearm is inefficient owing to Flail Shoulder.

humerus to the scapula, we are enabled to secure the use of muscles attached to the shoulder girdle, and thus some elevation and a considerable adduction and abduction may be secured. This is the operation Vulpius particularly recommends, and the fixation may be strengthened by means of a silver wire through the head of the humerus and the bony rim. At the hip-joint it is extremely doubtful if the operation is ever necessary or permanent when performed. At the ankle and knee joints its performance is a matter of opinion, and in my experience parents much prefer the use of a light support, such as the light leg splint previously described, and boots stiffened and built up, to any operative interference.

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